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A WOOD REFUSE SUCTION GAS-PRODUCER.—(See page 3.)

Wheels, Ancient and Modern—III.*

From Log Roller to Wire-spoke Motor Car Wheel

By Henry L. Heathcote, B.Sc.

Concluded from Supplement No. 1878, page 429.

Having now shown the superiority of wire wheels as shock absorbers, under load and torque, under side torque driving and shock in a direction vertical to the plane of the wheel, I will give a brief outline of the tests that are regularly carried out in the Rudge-Whitworth research laboratories to maintain the standard of excellence. It will, perhaps, be convenient to start with the hub where the torque is applied, and proceed *via* the hub shell, spoke heads, spokes, nipples, and rim to the tyre.

Inner Hubs.—The inner hub, which is of steel, is keyed on to the axle and has a series of keys which engage with similar slots milled inside the hub shell (Fig. 11). The material is analyzed; its tensile strength, elongation, and contraction determined; and, as its main duty is to resist shear and transmit torque, test pieces are clamped in a vice and struck by an impact pendulum. From the sectional area of the piece, and the difference between the arc traversed after impact and the arc when there is no test piece in the vice, the energy absorbed per square inch can be calculated. The results are reported diagrammatically.

Definite limits have been arrived at for tensile strength, elongation, and impact resistance, above which all samples must be before acceptance. The strength of the threaded end is important, for it is a lock-nut screwed on to this that keeps the wheel on the car. The strength of the hub ends is regularly "proofed" by screwing the hub to be tested home into a fixed lock-nut and applying a very considerable torque graded to suit the size of the hub, and well up to the maximum ever likely to be applied.

Hub Shells.—These are drawn from sheet steel, and some types are all in one piece. About fourteen drawing operations, each followed by careful annealing, are required. Quite apart from the stresses the hub is subject to in use, this mode of manufacture itself exacts a very special quality of steel, and when it is remembered that a moderately-high elastic limit is required in the finished shell to resist the bursting stresses and the pull of the spokes, and that high elastic limit means greater internal stress and the formation of more brittle amorphous constituent during a given draw, it will be understood why the problem of successful manufacture was only solved after a long series of experiments on different steels, followed by the very closest supervision to maintain the uniformity of the steels selected.

Every consignment is analyzed and tested for tensile strength, yield point, elongation, contraction, and resistance to impact, not only as received, but after heating under conditions as to time and temperature similar to those obtaining during an annealing operation.

Every consignment is also microscopically examined for flaws, manganese sulphide, size of crystal grains, form of carbide, etc. As would be expected, the behavior in the drawing press is closely related to the elongation and contraction. Much depends also on the distribution of the pearlite and granules of cementite. One with a core rich in pearlite, but with decarbonized surfaces, may give much the same analysis as a steel with granules of cementite uniformly distributed throughout the ferrite, but the results in the press are very different. All reports on steels are typed on squared paper, and include a diagram (Fig. 12) embodying, as far as possible, all the experimental results that affect the mechanical properties. For instance, *A C* represents the tensile strength and *A Y* the yield point in pounds per square inch of a sample of motor hub-shell steel, *A B* its breaking elongation, and *A F* its contraction per cent. The area, *A B C*, represents in diagrammatic form the energy required to break one square inch of the steel by tension. Likewise, the area *A B E F* represents the ductility of the steel. *D B* is obtained by dividing the energy in inch pounds per square inch absorbed in breaking by impact, by half the breaking elongation, so *A B D* represents the energy per square inch required to break a test piece 1 inch by 1 inch. The corresponding triangles, etc., on the left, refer to the steel after annealing.

The rectangular areas, marked *C*, *P*, and *F* are calculated from the results of analysis, using the formulæ suggested by Campbell (*Journal of the* [illegible] *and Steel Institute*, 1904, No. 2, page 21), [illegible] class of steel. The area *C* represents the part of the tensile strength contributed by the carbon (or more accurately by the carbides and their distribution), and that marked *P* the part due to phosphorus. In this instance the manganese was not present in sufficient quantity to add to the tensile strength. The area marked *F* represents the tensile strength due to ferrite alone in this class of steel, and the rectangle, which is the difference between the observed and calculated tensile strength, represents the portion of the tensile strength added by the heat treatment and annealing.

Not only the hub shell, but also the spoke ring and the withdrawal ring that go to complete the outer hub are analyzed, tested, and microscopically examined in a precisely similar way. To check the correctness of the dimensions chosen for the hub shell, the finished shell was tested under torque, as already described, and under spoke tension—(1) by inserting spokes and pulling them in a Denison machine, and (2) by building up into a wheel and steadily increasing the tension (which was measured as described below) until permanent deformation occurred.

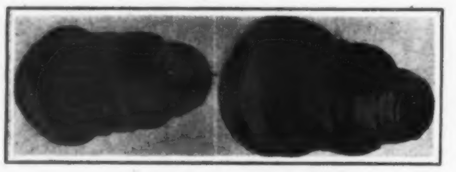


Fig. 11—Keyed Hub and Hub Shell.

To ascertain the resistance of hub shells to impact, wheels built up with experimental shells are tested with the impact pendulum. To check the care with which the annealing is done, tensile tests and analyses are made on pieces cut from the finished shells to see that the carbon is not "burnt off," and that the elastic limit is not lowered.

Spokes.—Though the great care exercised in choosing and maintaining the quality of hub-shell steel is necessary, still greater is that necessary in the choice and maintenance of suitable material, structure, dimensions, and design for the spokes. This is required because of the variation of tension to which they are subjected. An alternating tension test is used to subject them to variations like those experienced by a spoke in a wheel. In addition to this, all consignments of spokes are tested for tensile strength, elongation, and contraction, near the head and on the swaged part, and a longitudinal median section is examined microscopically to see if the pearlite grains have the dimensions that have been found most suitable. The microscope also detects undue internal strains set up during heading. Occasional analyses are made.

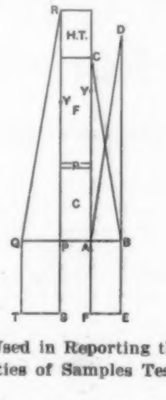


Fig. 12—Diagram Used in Reporting the Characteristic Properties of Samples Tested.

To check the accuracy of the initial tension on the spokes, wheels are taken at random from the stores and the tension on each spoke is measured. To do this, two spokes, one outside and one inside, are fitted into a hub, nipples screwed on, and a pull applied to the nipples in the Denison testing machine. The pitch of the notes emitted at different tensions by the spokes when twanged is then compared with whistles and tuning-forks. In this way a scale of tensions is found for each spoke which corresponds to a definite scale of whistle notes. The spokes in the *wheels* are then twanged, and their pitch—and therefore tension—ascertained by these whistles. The spoking machine now used in building these wheels [illegible] far to insure uniformity of tension.

The microscope has proved useful in controlling the spoke threads. The threads on Rudge-Whitworth motor (and cycle) spokes are not cut in, but rolled out of the metal. In this way the diameter and strength obtained at the base of the thread are greater, for the rolling process jumps up the metal, strengthening it by the cold working it gets. With the microscope the actual displacement of the metal can be accurately followed by observing the positions taken up by the pearlite grains, and the degree of cold working at various parts of the thread can be gaged. Lines of weakness can be detected at once, as also imperfection in the outline.

Nipples.—The material from which the nipples are made has to be of high tensile strength. Consignments are tested for tensile strength, elongation, and contraction. They are also analyzed and occasionally tested with the impact tester. Of course, nipples and all other parts of these wire wheels have their essential dimensions gaged by a large staff of expert viewers, but as this work—though scientific in so far as "science is measurement"—is really outside the work of the laboratory, it is omitted from the present account.

Rims.—The stresses to which rims are subject are complex. As already pointed out, load bends the rim, flattening it where the load is borne. This varying flexure will spread to the rim bead, making it bend and unbend to a slight degree. Another and more important cause of the bead bending is due to the tendency of the cover to pull away. This is proportional to the air pressure and the radius of the air tube section. For a tyre pumped up to 90 pounds per square inch, and with an inner tube 4 inches in diameter, the force on 1 inch of the bead and perpendicular to it will be 180 pounds. This force will vary in magnitude, being greater near the ground and when rounding a corner, and will call into play transverse strains.

In testing rims, therefore, a section one inch wide is taken and tested by applying a pull to hooks made to imitate the bead of a motor tyre, and the elastic limit and yield point recorded. The tensile strength, elongation, and contraction are determined of pieces cut transversely as well as lengthwise, and the rims are occasionally analyzed, tested for resistance to impact and microscopically examined.

Tyres.—Although tyres are somewhat outside the limits indicated by the title, the influence of the wheel on the tyre is too close to omit reference to them. One characteristic feature of wire wheels that contributes to reducing the tyre depreciation, viz., power of absorbing shock, has already been mentioned. There are others. The rise of temperature of tyres after a quick run is familiar to all. The hand cannot be held on the treads, cold water is converted into clouds of steam, and actual measurements on racing car tyres (*Automobilia*, August, 1908) show that at 135 kilometers per hour the temperature reached by the cover and air tube were respectively 132 deg. C. and 96 deg. C. This is in part due to friction between the ground and the tyre tread just as it is leaving and retouching the ground owing to the inequalities of the road surface, etc., in part to friction in the canvas or fabric, and in part (and probably in greater part) to the fact that when the stress in rubber is considerable, and its temperature is a few degrees above 8 deg. C., both extension and compression cause rise of temperature (Todhunter and Pearson's "History of Elasticity," vol. ii., part 1, page 477). As the temperature of the tyre rises, the tensile strength of the rubber diminishes, and the energy stored in the rubber and not returned on leaving the ground increases rapidly. This not only leads to further rise in temperature, but to further softening, greater elastic hysteresis, and to increased resistance to the forward motion of the four wheels. From measurements made by the Palmer Tire Company, the loss for one tyre may be as high as one-half horse-power. The bearing of this on the construction of wheels is that the steel rim, which conducts much of the heat away, is, in the case of a wire wheel, able to leave its heat behind, whereas the wood felloe (which has only one fourteen-hundredth the conductivity of steel) insulates the rim of the wood wheel just where cooling is most needed. Bearing in mind that the cost of rubber tyres is something like 23 per cent of that of the raw material used in a 14 horse-power live-axle motor-car, the urgent need for something to mitigate the cost of their upkeep can readily be grasped.

The cost of tyres, including one spare, for such a car varies, of course, but taking it at £40 ($200) per set of five, their cost is about 13 per cent of the finished car. Rudge-Whitworth wire wheels for such a car would cost (not including inner hubs) about £17 10s. ($87.50), or 5.8 per cent, and, needless to say, the depreciation due to use is far less on this 5.8 per cent than on the 13 per cent due to the tyres. Unfortunately, I have no figures comparing the wear of tyres on Rudge-Whitworth wire wheels with the wear on other wheels, but the impression that wire wheels really do save the tyres is steadily gaining ground among motorists.

SOME OTHER MODERN WHEELS.

The defects and cost of tyres have led to a quickening

* Paper read before the Royal Society of Arts and published in its *Journal*.

of interest in spring wheels, and many attempts have been made to obtain sufficient resilience by employing springs in place of air inclosed in rubber.

In 1906 a spring-wheel contest was held in France. There were thirteen entries, two cars forfeited, and one was put *hors de combat* by an accident while landing at Boulogne. Of the ten that started, six depended for their resilience upon the application of rubber, and four used metal springs only. The only three that finished the 1,300 miles were of the rubber type; the metallic springs broke down early.

The chief defect in spring wheels, and one that is inherent in the system, is the considerable mass of steel that is required to give the necessary resilience. This is consequent on the numerical value of the elasticity of steel and the high factor of safety necessary under alternating stress.

The greatest amount of energy that can, without permanent set, be absorbed by a spiral spring of solid wire weighing 1 pound is about 50 foot-pounds. This figure can be doubled by employing a hollow spiral tube with thin walls. A straight wire of spring steel weighing 1 pound will safely absorb 60 foot-pounds. The shocks due to irregularities and obstacles on the road may reach many thousands of foot-pounds, and since the energy to be absorbed varies as the square of the velocity, it is obvious that for high speeds inclosed air, which will take up a practically unlimited amount of energy, is much more suitable than springs.

In the Reid-Reikie spring wheel there are sixty-four spiral springs, each weighing 3 pounds, or nearly 200 pounds for springs only in each wheel, and each spring has a free radial movement of only about one-quarter inch.

An improved spring wheel capable of transmitting drive to the outer rim was invented by the Hon. R. C. Parsons, and many other types are to be found in the publications of the Patent Offices.

Railway wagon wheels are now usually made of steel. The flanged tyre is rolled from a punched billet and shrunk on to the wheel. This is usually of cast steel, and is forced on a forged steel axle.

The steel wheels made by the Shrewsbury and Challiner Tyre Company are built up by welding *H* and *T* section girder-steel spokes to steel flanges at the center and steel rims by means of the oxy-acetylene blow-pipe. When *T* section steel is used for the spokes they are arranged on two cones intersecting at the rim. The wheels used on the London Omnibus Company's motor omnibuses are of cast steel.

Thorneycroft truck and traction engine wheels have spokes made of flat steel-plates bolted to flanges on the rim. Usually the spokes are on two cones intersecting between the rim and the hub.

The Sankey wheel for motor-cars is made of sheet steel and looks much like an artillery wheel. By means of a number of stamping and drawing processes, a plain disk of steel is molded into the shape of a half wheel. These halves, welded together by oxy-acetylene, form a light wheel which possesses considerable strength.

Fig. 13 shows a line drawing of hydraulic rams used for building wood wheels. A wheel-setter, built much on these lines, is used at the Royal Woolwich Arsenal, where the practice is to heat the iron tyre, but not to red heat. The degree of compression produced by the contraction of the tyre depends on the yield-point of the metal, and this is very low in red-hot iron; consequently, after putting on the hot tyres, the rims are used to compress both tyre and wheel, the final tightening being performed by the contraction of the rim.

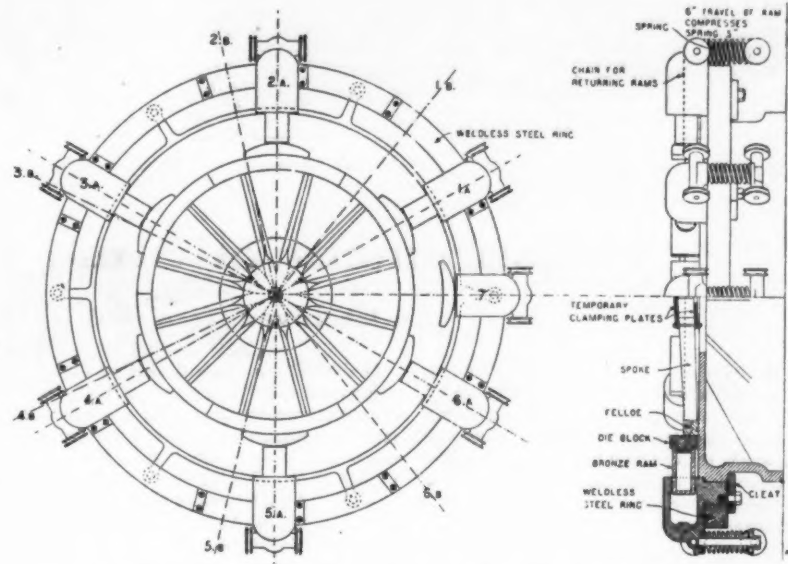


Fig. 13—Set of Hydraulic Rams Used for Building Wood Wheels.

An English Wood Refuse Suction Gas Producer

Power from Low-Grade Fuel

THE English wood refuse suction gas producer seen in operation in the accompanying illustration was designed and constructed at Lincoln, England, and is intended to produce cheap power from sawdust, wood-blocks, chippings and bark as a fuel.

This wood refuse suction gas producer is of the Ruston type and is said to be very successful in Great Britain. It is true that ever since the introduction of the suction gas producer, engineers have been experimenting with various types of construction to enable low grade and cheap fuels to be used. It is well known that all kinds of wood contain the necessary properties for making gas suitable for use in gas engines, the only difficulty being the efficient cleaning of the gas and the prevention of the choking up of the gas pipes, ports and valves.

It is claimed that the troubles previously experienced from this source have been entirely overcome in this producer which has worked successfully with sawdust, wood-blocks, chippings, bark and wood refuse. In addition to these fuels peat, lignite, brown coal and similar fuels have been used.

It may be stated that one of the principal new features of the producer is the special arrangement for cleaning the gas outlets during operation, which does away with the usual week-end cleaning, so that the plant can be worked continuously if required.

Among the many advantages and important features of this wood refuse suction gas producer may be mentioned the small space required and the fact that there is no coke scrubber to become clogged up with tar, consequently no periodical changing of the coke. The attention required is also reduced to a minimum. The machine is simple in construction and the gas is free from grit, dust and tar. The producer is also suitable for working efficiently on anthracite, coke or charcoal, in the event of the common fuels giving out.

The consumption of wood refuse is stated as ranging from 2½ to 3½ pounds per brake horse-power, according to the amount of moisture in the fuels. The plant will produce approximately 4 to 5 times the power as when the fuels are burned for direct steam raising. As to continuous working, it may be mentioned that the whole plant is designed to obviate the stoppage for cleaning, which is usual with gas providers. The little cleaning required can be accomplished in a few minutes while the plant is in operation without interfering in the least with the quality of the gas.

The suction gas engines are made with single cylinders from 9 to 130 brake horse-power and 150 to 260 brake horse-power with double cylinders. The governor is of the variable admission type, controlled by a special gear, by means of which the opening of the inlet valve is regulated in accordance with the load on the engine, the proportion of gas and air remaining constant.

The Government as a Coal Purchaser.*

By ADDISON J. PARRY.

IN its annual report of expenditures, the Government budget shows an item of $7,000,000 for coal. It is interesting to note the various uses of coal by the different Governmental Departments. Five departments are very large consumers; these are the Navy, War, Treasury, Interior, and Commerce and Labor. Much of the coal used by the Government must be delivered by wagon, and the business is therefore limited to dealers having hauling facilities. This is especially the case in the City of Washington, where coal is purchased principally for heating the public buildings.

The Treasury Department is a large consumer of coal delivered in wagons; the fuel required for post-office, custom house, United States court houses, marine hospitals, mints, and other federal buildings throughout the country is purchased throughout by this Department, which also buys for the Revenue Cutter Service.

The Navy Department is a large car-lot consumer as well as a purchaser of large cargoes of coal for foreign delivery. The Bureau of Supplies and Accounts of this Department purchases the larger quantities for the ships of the navy and the car lots for use in the navy yards.

The War Department makes purchases of coal for the many forts and army posts in the United States and foreign possessions and for the ships in the army transport service. The car-lot consumers are the Ordnance Department, which buys coal for the arsenals, and the Engineer Corps, which buys fuel for use in river and harbor improvement and other construction work.

The Department of Commerce and Labor purchases coal for the vessels of the Coast and Goedetic Survey and for the Immigration Service. At the Ellis Island Immigration Station New York, 10,000 tons, mostly bituminous coal, is bought annually. Fuel for the light-houses is purchased by this Department, the service being divided into sixteen districts, for each of which a separate contract is made. Each of these contracts covers 1,000 to 13,000 tons and calls for anthracite and bituminous coal. The Bureau of Fisheries is a consumer of anthracite and bituminous coal in small lots, delivered to the cars of the Bureau and to its stations throughout the country.

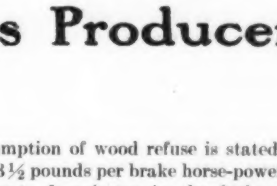
The Interior Department is a large consumer of coal in Washington, where it purchases annually 20,000 tons of bituminous and 1,000 tons of anthracite for the Government Hospital for the Insane. Outside of Washington, this Department's most important contracts are those for coal to be delivered to Indian schools and agencies.

Most of the coal purchased by the Government is used for warming public buildings and for generating power, though small quantities of blacksmith's or forge coal and coke are bought. The larger individual contracts are those for bituminous coal and the small sizes of anthracite. The larger sizes of anthracite are, as a rule, purchased in small lots and delivered mainly by wagons.

* *The Yale Scientific Monthly.*

To Tighten a Loose Screw.

A HINT which may be useful in an emergency is given in *Machinery*. A screw too small for its hole, was placed between wooden jaws in a vise and a slot made as shown in the sketch. A flat iron wedge was driven into this slot, springing the screw slightly, when it fitted snugly into its place.



To Tighten a Loose Screw.

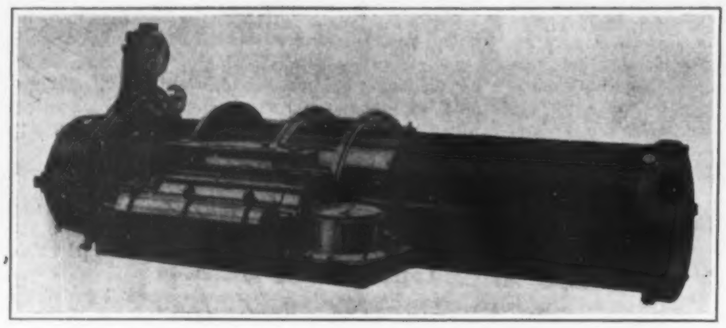


Fig. 1—Torsion Meter With Indicating and Recording Gear.

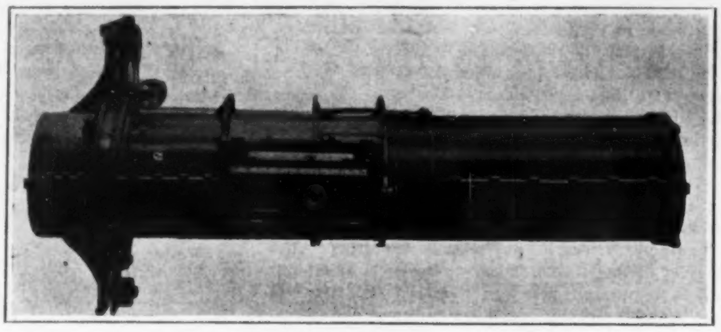


Fig. 2—Torsion Meter With Indicator Only.

Measurement of Shaft Horse-power*

An Improved Torsional Dynamometer

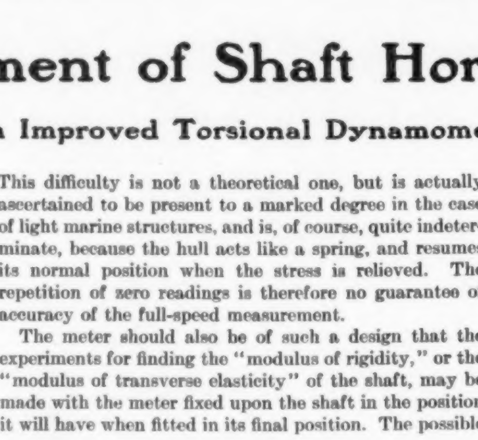
The accurate measurement of power transmitted along a shaft by means of a torsion meter or torsion indicator no doubt owes its origin as a real practical engineering operation to the advent of the steam turbine. The probable power of a steam turbine may be arrived at mathematically by calculations of pressure and speed, and it may also be obtained after construction by means of a series of actual steam pressure readings taken at different stages of expansion of the steam and so converted into power. Neither of these methods is altogether satisfactory, so that the twist of the shaft is now almost universally used to measure the power. Needless to say, the torsion meter must be a very exact instrument if it is to give accurate readings. The amount of mean angular movement of the shaft due to twist is rarely more than one degree on about 10 feet of length in a shaft running uniformly, such as the shafting of marine turbines, and this is a small amount to measure when the shaft is revolving at a high speed, as it usually is. There are, of course, many types of torsion meter, mechanical, flash-light, and electrical, but more important than the particular method adopted is the question whether the meter is of a type which measures the twist at one point of the revolution only, by means of a succession of rapid flashes of light reflected from a mirror, or transmitted through slits in two or more disks, or whether it gives an actual all-round measurement of the torsion, embracing all parts of a revolution.

Obviously, a measurement based on a succession of instantaneous "spot" readings may be of a more or less constant nature, because they are necessarily always taken at the same point of revolution of the shaft, and yet it may be quite inaccurate as an indication of torsion. To take an extreme case, if a meter giving an instantaneous spot reading were put upon the shaft of a reciprocating engine, a more or less steady reading would be obtained, depending upon the particular phasing of oscillation of the shaft, but it might indicate twice the mean torsion which represents the real shaft horse-power being transmitted, or if placed at another point the indication might actually be a negative one. The violent torsional oscillation caused by the impulses of the different pistons, combined with propeller and other effects, does not occur in a turbine shaft; but oscillations due to propeller, shafting, and wake of the ship are still present, so that it is always safer to use an instrument which gives an "all-round" reading, because the "spot" reading gives no indication of such a variation if there be one. It should further be observed that in a reciprocating engine shaft the torsion thus read may be still variable in spite of being taken at only one point of a revolution, for in addition to the variations of torsion during one revolution, there is also a very large super-added variation over several revolutions, so that torsion at the same point does not lie in a straight line parallel to the zero line, but upon a wavy line which represents the super-added phases of oscillation. Hence a diagram, built up from a series of "spot readings" taken at different parts of a revolution is not only a difficult and lengthy operation, but also an inaccurate one in many cases. The other important feature is to see that the instrument is so designed as to be wholly independent of the relation between the shaft and the surrounding supports. For land installations solid foundation is usually to be got, and slackness in bearings is the only real difficulty, but in marine work an instrument, part of which is supported from the ship, is liable to error due to deformation of the ship's structure when being driven at high speed. This feature is especially noticeable in torpedo boats and destroyers, where the structure is extremely light and the power very great, and on readings so minute this may, and does, cause very appreciable error. To be accurate, then, the meter should be practically a part of the revolving shaft, and independent of supports which may change their position relatively to it. This difficulty is not a theoretical one, but is actually ascertained to be present to a marked degree in the case of light marine structures, and is, of course, quite indeterminate, because the hull acts like a spring, and resumes its normal position when the stress is relieved. The repetition of zero readings is therefore no guarantee of accuracy of the full-speed measurement.

The meter should also be of such a design that the experiments for finding the "modulus of rigidity," or the "modulus of transverse elasticity" of the shaft, may be made with the meter fixed upon the shaft in the position it will have when fitted in its final position. The possible error due to a separate calculation of the modulus, and its application to the ascertained twist, is not a large one, but there is a source of error, due to a possible variation of diameter of shaft, either outside, or both inside and outside in a hollow shaft, and to a possible want of absolute homogeneity of the metal, allowances for length of couplings and fillets, small movement at coupling bolts, etc.

If the meter be so designed that it can be fixed to the shaft, and the necessary turning moment applied, its readings may be plotted in terms of actual turning moment, and all these sources of variation quite eliminated. The torsion meter reading will then be a direct measure of turning moment, which when combined with revolutions gives the shaft horse-power. This is so obviously true, and so simple, that it is adopted as standard practice now by all those who realize the great value of shaft horse-power readings obtained by means of a torsion meter.

If, in addition to these qualities, the meter be capable of giving not only an easily read indication at a pointer, but also, if required, an accurate diagram of the torsion and its variations, with an accompanying simultaneous record of revolutions, we have a complete method of getting an accurate indication of shaft horse-power at any moment, and a permanent record for subsequent examination. With such an instrument an interesting record of the variation of torsion during the process of reversing a turbine-driven steamer, or of cutting in an emergency throttle valve, or other similar operation, is easily obtained.



Figs. 3-4—Indicator and Recorder for Denny-Edgecombe Torsion Meter.

The engravings we give herewith are from photographs of four Denny-Edgecombe recording torsion indicators in which all these requirements are, it is claimed, fulfilled. They have been made to the order of the Royal Italian Navy, for the new dreadnought "Dante Alighieri." Fig. 1 shows the instrument complete, with recording gear for taking diagrams, and Fig. 2 shows it arranged simply for indicating torsion on a scale and vernier. Fig. 3 shows the details of the indicator alone, which is designed to give the readings of torsion in a straight line, so that the recording apparatus seen in Fig. 4 may be directly applied to it, and continuous diagrams of torsion permanently recorded.

The meters shown are purely mechanical in type. There is the usual stump and sleeve made in halves, and secured to the shaft; the stump rigidly, the sleeve at one end only, i.e., that most remote from the stump. When the shaft is twisted the sleeve remains untwisted, so that the twist produces a relative but small movement between the arms of the stump and sleeve. This movement is magnified by fine multiplying gear at the end of the arms, and converted into longitudinal motion of a light aluminium traveler, carefully made and adjusted to run upon the outside of the sleeve. This is accomplished by a very flexible but strong wire rope secured at both ends to a drum on the multiplying gear and passing round a pulley anchored upon the shaft; the traveler being secured to the wire by a strong gripper. All the wheels and pulleys are mounted on ball bearings, and are almost frictionless, so that when the shaft is revolving the ordinary vibration ensures accuracy of position.

The flange of the traveler is thus made to move along the tube by the twist imparted to the shaft. If this were measured directly, however, we should be subject to a very serious error, for there may be, and as a matter of fact there always is, some longitudinal movement of the shaft itself due to thrust or expansion. This is eliminated by means of a base or dummy flange cast upon the sleeve and accurately turned. The traveler flange is made to fit accurately against this base flange for setting in position, and is then drawn along the tube and secured to the wire rope at a convenient distance from the base flange. The variation of distance between these two flanges will thus be an exact measure of the variation of torsion of the shaft.

An indicator, as shown in Fig. 3, is applied to these two flanges to magnify further the movement and make it easily readable. It has a metal frame, carrying a movable base plate borne on four ball-bearing wheels in grooves, and pressed upon by a spring at one end. This base plate in turn carries a small, light aluminium movable carriage with ball-bearing wheels also running in grooves on the back of the plate. Both the base plate and the movable carriage of the indicator have wheels, which run upon the two flanges of the torsion meter tube respectively. The wheel on the base plate of the indicator runs against the base flange of the tube, and is kept up against it by the end spring. The wheel on the movable carriage runs upon the movable traveler flange, and is kept against it by a tension weight, so that the relative movement of the flanges is transferred directly to the indicator when the shaft is revolving. Means are provided for keeping these running wheels out of contact with their respective flanges when not in use.

The small movable carriage of the indicator carries a double-toothed wheel, whose smaller diameter engages with a fixed rack upon the lower edge of the base plate, the larger gearing with a movable rack which is thus made to indicate the amount of twist, much magnified, and on a straight line. To get further magnification a small vernier wheel is attached to it with a moving pointer giving the readings on a still larger scale. The indicator box is supported in any convenient manner from the ship or ground, but, as will be seen, the indicator proper, being movable in its box, depends wholly for position upon its contact with the base flange of the meter, and is thus quite independent of any relative movement of the ship and the shaft; it is really a part of the revolving shaft.

This meter, it is claimed, is quite free from all the sources of error pointed out above, and is most suitable for statically testing the shaft to obtain its modulus.

* The *Engineer*.

There is another form of the Denny-Edgecombe torsion meter which will appeal to many from its simplicity and applicability to positions which are inconvenient for personal observation, and where it is not specially desired to obtain permanent records of the revolutions and torsion. It is particularly suitable as a permanent fitting to shafting.

The principle involved is the same. Torsional movement is magnified by the multiplying gear at the end of the arms, but instead of applying this movement to a traveler on the tube by means of a flexible wire, the movement is transferred electrically to a strong type of ammeter which may be fitted up in the engine room or in any part of the ship. Duplicate ammeters may also be fitted, so that it is possible to read torsion simultaneously in the engine-room, the chief engineer's cabin, and the captain's cabin. The instrument is a robust electro-mechanical combination, and, it is stated, as simple to read as a pressure gage. By simply pressing a button the torsion of the shaft may be read immediately, and the shaft horse-power obtained at once. The ammeter is provided with an adjuster which compensates for any drop in voltage, but such variations are necessarily small, because the ammeter is differentially wound and so compensates automatically for such a change. Current is supplied from a small accumulator, which may be recharged at long intervals.

This design of torsion meter may be applied to the shafting of any type of engine, whether turbine, steam reciprocating, or internal combustion. There should be no difficulty with these fittings in having shaft horse-power logged regularly on board ship as simply as pressure or revolutions are at present.

For turbines, the information so acquired is especially valuable, as any internal change in the turbine such as blade stripping would be immediately discovered by comparing the steam pressure at the high-pressure end with the resultant shaft horse-power as given under normal conditions, assuming the propeller to be unchanged. Then, too, a complete record of shaft horse-power over the whole voyage can be obtained. The relative values to be attached to trial conditions and sea conditions would be at once indicated by this means. Other applications will occur to every engineer who has charge of a power plant.

Prevention of Importation of Insect-Infested or Diseased Plants

THE effort to secure national legislation to keep out new and dangerous insect pests or plant diseases, which may be brought in with imported nursery stock, has been actively favored by the Department of Agriculture. In the case of domestic animals the exercise of such powers has brought enormous benefit. It is reasonable to believe that like benefits to fruit and forest interests, including the nursery stock business, will undoubtedly come from similar legislation to exclude insect pests and plant diseases.

The immediate danger which led to the recent effort to secure legislation was the discovery in 1909 of the abundant importation and wide distribution into the United States of nursery stock infested with brown-tail moth nests and occasional egg masses of the gipsy moth. During the years 1909 and 1910 such infested stock was carried into 22 States, covering the country from the Atlantic seaboard to the Rocky Mountains. During the first of these years no less than 7,000 winter nests of the brown-tail moth, containing approximately 3,000,000 larvæ, were found in shipments into New York State alone—seed material enough to infest the whole United States within a few years. During the second of these years, 617 of these nests were found on nursery stock shipped into the State of Ohio, and a much larger number, approximately the same as the year previous, were again sent into New York. Smaller numbers of these nests, proportioned to the amount of nursery stock received, were sent into other States east of the Rocky Mountains during both of these years. Fewer brown-tail moth nests were received during the season just ended (1910-11), owing to the agitation in this country, and more strict supervision by foreign Governments. These winter nests are, however, still coming in, and the danger is now perhaps even greater, for the reason that as infestation becomes more infrequent a laxity of examination results.

So far as possible, this stock, as voluntarily reported by customs officers and railroads, has been examined and the brown-tail nests removed or destroyed by State authorities, or, where these were not available, by agents of the Bureau of Entomology of the United States Department of Agriculture. Undoubtedly many shipments have not been reported or examined, and it is quite probable that local infestation has already started at different interior points. The history of both the gipsy and brown-tail moths in New England shows that these insects may be present for several years without being noticed, slowly gain headway, and then suddenly develop their full power of destructiveness.

It is scarcely necessary to comment on the danger to this country from the careless introduction and wide distribution of these two orchard and forest pests. In a limited district in New England more than a million dollars a year has been spent for a long period in a mere effort to control these two insects, and the General Government is now appropriating $300,000 annually to endeavor to clear them from the border of main highways and thus check their spread. These expenditures do not take into account the actual damage done, but they do serve as a measure of the danger to the whole country from the recent distribution of these two insects on imported nursery stock.

As further illustrations of the constant risk from lack of legislation may be mentioned two very recently introduced insects which will undoubtedly prove very expensive pests in future years. The European alfalfa leaf-weevil, on the authority of the entomologist of the Utah Experiment Station, Mr. Titus, was probably brought into Utah on the packing of nursery stock or other merchandise from Europe. This leaf weevil has already destroyed much of the value of the important alfalfa crop of Utah, and is spreading into adjacent States. The other illustration is the oriental cotton scale (*Pulvinaria psidii*), probably the worst scale pest of citrus and other subtropical plants in southern Asia. This scale insect has recently been introduced into Florida on imported stock and is already well established there.

New plant diseases, against the entrance of which there is at present no bar, may even more seriously jeopardize the farm, orchard, and forest products of this country. Imported potatoes from Newfoundland are now bringing in the potato wart disease, which, wherever it has been introduced in Europe, and also in Newfoundland, puts a stop to potato culture. The importation of white-pine seedlings is now bringing in the European white-pine blister rust, which, if established and disseminated, will destroy much of the value of our white-pine forests. Absolute quarantine against these two plant diseases is the only means of keeping them out. The chestnut disease, now practically shown to have been introduced on trees imported from Japan, illustrates what may quickly happen from such unchecked introductions.

Accordingly a bill was recently introduced into both House and Senate, and it is expected to come up for consideration next winter at the first regular session of the present Congress.

This bill provides for importation of nursery stock by the same permit system which has been found perfectly satisfactory in relation to the importation of domestic animals. A certificate of foreign inspection is also required. The latter will not affect importation of plant products solely intended for food, and provides for importation of plants for scientific purposes, and also makes provision for importation from countries where no system of foreign inspection and certification is at present possible.

The law is also designed to afford the Government accurate information covering every package of nursery or other plant stock imported for propagation.

Foreign districts, or particular plant products in foreign districts, may be quarantined to exclude disease or insect enemies, which cannot otherwise be kept out of this country. The Department of Agriculture, according to circular No. 37, issued from the office of the Secretary of Agriculture, states that the department will not unnecessarily interfere in any way with legitimate importation of plants.

Districts within the United States where new diseases or insect enemies have gained a foothold, may also be quarantined.

Conditions calling for legislation are those set forth in the circular referred to.

Materials of Construction for Electric Resistance Furnaces.

THE substances employed for electric resistance furnaces are principally pure nickel, platinum, and carbon.

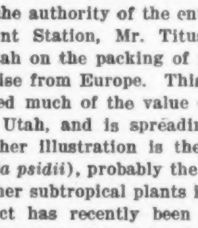
Nickel wire, while very cheap, cannot be employed at temperatures appreciably exceeding 600 deg. Centegrade (although it does not melt until 1,480 deg. Centegrade is reached), owing to the formation of oxides which increase its resistance and also render it brittle. The wire is used either covered with enamel and sunk in a metal plate which constitutes the heating body (Elektra system), or else the wire is inclosed in quartz tubes (Schoen system).

The same arrangement is used for platinum furnaces, which have the disadvantage of being costly and heating slowly. Carbon furnaces are generally preferred. In these the resistence is formed of arc carbon (Borchers system) or of granulated carbon such as the material known as kryptol, or the so-called resistol. Kryptol can be used up to 3,000 deg. Centegrade; being a poor conductor, however, it must be employed in thin layers.

In tube or muffle furnaces excellent heat insulation may be obtained by means of the arrangement shown in the engraving, which is reproduced from the *Revue Electrique*. The substance to be heated is placed in a quartz tube B, surrounded by a layer K of kryptol, placed between two carbon electrodes AA^1. This layer of kryptol is insulated by a quartz tube C, covered with magnesia or kaolin; next comes a layer of air D, and lastly a thick layer of kieselguhr or scoria, E.

The drawback of the kryptol heating system is that the resistance material is combustible in contact with air. This disadvantage is reduced as far as possible by suitably packing the material and avoiding active air circulation in the neighborhood of the furnace.

In conclusion, attention may be drawn to the resistance material known as silundum, a carborundum pre-



pared by a special method, and practically incombustible up to 1,000 deg. Centegrade.

Roman Surveying.

IN the *Zeitschrift für Vermessungswesen* Prof. E. Hammer discusses the precision with which the nations of antiquity were able to mark out lines on the surface of the earth with the means at their disposal. Taking, first, that portion of the frontier of the Roman Empire which existed as a straight line about 50 miles long from near the River Rems in Württemburg to the district of Wallfürn in Baden, he investigates the question whether this line was laid down approximately straight by chance, or whether it was intended to be a straight line and special care was taken to arrive at this result. Points on the line were located and their positions plotted on the cadastral maps (scale 1:2500) from which their co-ordinates were determined. From these the direction-angle of portions of the line was calculated, and also the mean departure of points on the boundary line from the true straight line. For a portion amounting to 29 kilometers of the whole length, the mean error in position of a point on the boundary was found to be ±2 meters, which indicates a surprising accuracy in carrying such a line over rough ground, while for portions of it an even greater precision was attained. Further observations by Prof. Leonhard, not yet published, on the remaining 30 miles of the boundary indicate that the accuracy is there maintained. The Romans must have fixed a few principal points in prominent positions by signals at night, and then interpolated intermediate points; the observed accuracy could never have been attained by prolonging a line.

A second case is that of the amphitheater at Pola, laid out by a Roman architect or land surveyor, which has been recently studied by an Austrian surveyor, Herr Hofrath A. Broch. Using a plan on a scale of 1:250, he investigated the accuracy with which the form of the amphitheater as constructed approached an ellipse. Taking twelve points on the curve, their mean error in position from a true ellipse was but 15 centimeters, in spite of the weathered surfaces of the stone contributing to this uncertainty. The axes of this ellipse were $2a = 129.9$ meters and $2b = 102.6$ meters, or in the ratio of very nearly 9:7, as in the case of many Roman amphitheaters. Prof. Hammer goes on to refer to the results obtainable in a similar way from stone circles, where it is important to determine not only their dimensions, but also their accuracy of construction. The accuracy attained at Stonehenge is referred to; and in mentioning the "Standing Stones of Stenness" he suggests that in the circle of 340 feet in diameter, formed of about 60 stones $17\frac{2}{3}$ feet apart, we may have had a circle of 60 stones exactly ($60 \times 17\frac{2}{3} = 1060$) indicating a sexagesimal division of the circle.—*Nature.*

The Orbit of Beta Persei*

The Spectroscopic Study of a Binary

By J. B. Cannon

THE star *b* Persei (α = 4 hours 10.7 minutes, δ = + 50 degrees 3 minutes, mag. 4.5) was announced a binary by Prof. Campbell early in 1910 from measures of four plates taken, two in 1903, one in 1906 and one in 1909. Its spectrum is of *A* type and a few of the plates obtained here show double lines. In the second spectrum thus appearing, the lines are not at all well defined and measures on them are only fair as will be seen by the magnitude of the residuals. The lines which show doubling are H_γ, and H_δ and in one case the iron line λ4,045.

There were taken in all thirty-six plates dating from October 10th, 1910, to April 24th, 1911. The lines are about the average for this type. Being a double spectrum and the two components being separable in only a few plates, the measuring is more difficult than it would otherwise be

The lines measured were:

Element.	Wave-Length.
Hydrogen	4861.527
"	4340.634
"	4101.890
"	3970.177 [2]
Magnesium	4481.400
Iron	4549.766
"	4045.975
Calcium	3933.825

A table of observations is given at the end of this article. The phases are from corrected periastron, the residuals from the corrected curve. A table of the Lick observations is attached showing the residuals they give from the curve accepted.

LICK OBSERVATIONS.

Julian Day.	Phase.	Velocity.	Residual.
2416422.924	1.2092	+28.3	—12.5
435.989	1.4283	— 3.5	— 0.5
7473.978	0.8397	+49.5	— 6.3
8552.017	.5908	+52.5	+12.5
960.909	.1610	—31.4	— 9.6

The observations were combined into fourteen groups and these normal places used in obtaining, by means of Dr. King's graphic method, preliminary elements for the orbit. The normal places with mean velocities, mean phases, weights and residuals from final curve are given below:

NORMAL PLACES.

	Julian Day.	Phase.	Velocity.	Weight.	Residuals.
1	2419045.213	.464	+ 21.7	1	—2.21
2	100.036	.590	+ 39.6	2	+ 1.04
3	099.214	.682	+ 48.3	2	+ 1.66
4	068.496	.810	+ 49.4	1.5	—4.64
5	073.649	.961	+ 56.7	2	—0.10
6	069.281	1.020	+ 55.4	1	—0.37
7	078.533	1.137	+ 52.5	2	+ 3.41
8	018.838	1.197	+ 43.5	1	+ 0.77
9	064.280	1.312	+ 19.8	2	—3.93
10	116.991	1.399	+ 6.0	1.5	+ 1.88
11	018.730	1.472	— 8.9	.5	+ 3.52
12	017.472	.100	—27.3	1.5	—0.83
13	085.016	.252	—12.6	.5	—3.81
14	082.780	.318	+ 4.1	1.5	+ 2.11

The preliminary elements obtained were:—

$P = 1.52732$ days $\quad K = 43.5$ kilometers

$e = .25$ $\quad \gamma = 21.92$ kilometers

$\omega = 150$ degrees $\quad T = 2{,}418{,}956.145$ J. D.

A least squares solution was carried through with the result that the following corrections were made to the elements:

$\delta\ \gamma = +\ 1.20$ kilometers $\quad \delta\ \omega = +\ 0.85$ degrees

$\delta\ K = -\ 1.925$ kilometers $\quad \delta\ T = +\ 0.018$ days

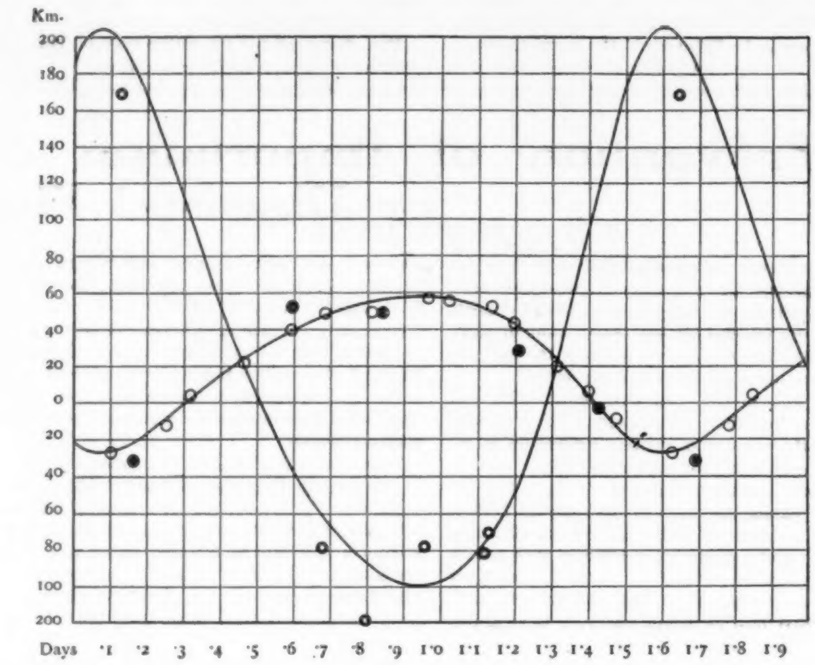
$\delta\ e = -\ .038$

The value of Σpvv was greatly reduced, being brought down from 241 to 128. Disagreement between computed and observation equation residuals led to a second solution being made and further corrections found:

$\delta\ \gamma = -\ .03$ kilometer $\quad \delta\ \omega = +\ 0.90$ degree

$\delta\ K = +\ .31$ kilometer $\quad \delta\ T = +\ .0035$ days

$\delta\ e = +\ .008$



VELOCITY CURVE OF *b* PERSEI.

The new values for the elements gave satisfactory comparison between computed and observation residuals and a second lowering of Σpvv from 128 to 126. The probable errors of the elements were computed and are given below after the final values of each.

The following table gives a summary of the values of the elements preliminary, first corrected and final:

Elements.	Preliminary.	First Corrected.	Final Values.	
P	1.52732 days	1.52732 days	1.52732 days	
e	.25	.212	.22	± .021
w	150°	150°.85	151°.75	± 2°.08
K	43.5 km.	41.575 km.	41.89 km.	± 0.97
y	21.92 km.	23.12 km.	23.09 km.	± 0.57
T	2418956.145	2418956.163	2418956.166	± 0.02
$a \sin i$			837,600 km.	

Coming to the secondary, only six plates showed lines measurable. No attempt was made to get elements independently of the primary, the number of plates not being considered sufficient for that. The value of γ and T finally accepted for the primary were taken for the secondary, ω_1 taken 180 degrees + ω, and the K was obtained by trial graphically. Those given probably suit the six observations as well as any. The elements are:

$P_1 = 1.52732$ days $\quad K_1 = 152.5$ kilometers

$e_1 = 22$ $\quad \gamma_1 = 23.09$ kilometers

$\omega_1 = 331.75$ degrees $\quad T_1 = 2{,}418{,}956.166$ J. D.

$a_1 \sin i_1 = 3{,}048{,}000$ kilometers

The relation existing between the masses of the two bodies is given by $M : M_1 = K_1 : K = 152.5 : 42$ or $3.6 : 1$.

The figure gives the two curves. The double circles are the observations on secondary component and the double circles with central dot are Lick observations.

Dominion Observatory, Ottawa, Can., June, 1911.

Plate.	Julian Day.	Phase Corrected from T.	Velocity (Primary).	O—C Residual.	Velocity Secondary.	Residual.
3728	2418955.830	1.191	+ 35.4	— 7.6		
3738	957.760	.067	— 27.6	— 1.6		
3809	985.63	.445	+ 12.8	— 9.2		
3819	9011.72	.561	+ 41.8	+ 5.3		
3826	012.79	.114	— 36.6	— 9.5		
3854	016.72	.989	+ 51.3	— 5.2		
3862	018.73	1.472	— 8.9	+ 4.1		
3870	021.62	1.297	+ 9.2	—16.8		
3875	022.64	.800	+ 50.7	— 3.3		
3885	027.54	1.118	+ 51.9	+ 1.4	— 81.5	— 5.0
3907	036.715	1.129	+ 59.7	+ 9.7	— 70.4	+ 1.6
3919	042.719	1.024	+ 51.0	— 5.5		
3931	049.680	.349	+ 4.4	— 2.6		
3939	053.724	1.338	+ 24.2	+ 6.7		
3949	054.792	.878	+ 59.3	+ 2.8		
3960	055.666	.225	— 10.0	+ 3.0		
3963	056.642	1.201	+ 48.4	+ 6.4		
3996	083.610	.678	+ 43.3	— 3.7	— 78.7	—16.7
4005	088.530	1.016	+ 59.0	+ 2.5		
4017	093.510	1.414	— 3.3	— 2.8		
4018	095.490	.340	+ 5.8	± 0.0		
4031	096.530	1.379	+ 14.1	+ 2.0		
4033	097.643	.965	+ 60.2	+ 3.6		
4034	098.491	.286	+ 3.1	+ 6.6		
4057	102.549	1.289	+ 20.8	— 6.7		
4068	103.580	.793	+ 45.3	+ 3.7	—119.0	—33.0
4078	104.583	.269	— 14.3	— 8.3		
4087	106.542	.700	+ 55.6	+ 6.6		
4100	109.560	.664	+ 45.4	— 0.6		
4112	110.550	.127	— 22.7	+ 2.5	+ 168.8	—28.2
4135	120.542	.955	+ 58.7	+ 2.0	— 77.3	+ 22.7
4143	124.658	.489	+ 33.5	+ 5.5		
4176	137.542	1.154	+ 47.8	— 0.2		
4185	2419138.536	.621	+ 34.4	— 7.6		
4195	141.550	.580	+ 42.1	— 4.9		
4246	151.542	1.409	+ 3.5	+ 2.5		

* Reproduced from the Journal of the Royal Astronomical Society of Canada.

[2] Only in one or two plates.

The Marine Steam-Turbine from 1894 to 1910—I.*

A Review of the Development of the Art

By the Hon. Sir Charles A. Parsons, K. C. B., D. Sc. LL.D., F.R.S., Vice-President.

THE application of the steam-turbine to the propulsion of vessels was entertained as early as 1884, but its development was not seriously considered till 1892, when the economy of the condensing turbine as applied to driving dynamos had excelled that of the compound reciprocating engine for the same purpose.

A pioneer association, called the Marine Steam-Turbine Company, Limited, was formed in 1894, whose object was the investigation of the subject. The prospectus opened with the following paragraph:

"The object of the company is to provide the necessary capital for efficiently and thoroughly testing the application of Mr. Parsons's well-known steam-turbine to the propulsion of vessels. If successful, it is believed that the new system will revolutionize the present method of utilizing steam as a motive power, and also that it will enable much higher rates of speed to be attained than has hitherto been possible with the fastest vessels."

From the first it was obvious that the turbine was suitable to fast rather than to slow vessels, and, consequently, it was decided to commence by building an experimental vessel of the smallest size consistent with the possibility of attaining exceptional speed. This vessel, the "Turbinia," 100 ft. in length, 9 ft. beam, 6 ft. in depth, and 42 tons displacement, after many alterations to her machinery, developed 2,400 horse-power on trials, and attained a maximum speed of 34½ knots. The machinery and trials of the little vessel were fully dealt with in the report of Professor J. A. Ewing, F.R.S., to be found in the Appendix to the paper read before the members of the Institution in June of 1903.† The trials of the "Turbinia" threw some additional light on the phenomenon of cavitation, previously observed by Sir John Thornycroft and Mr. Sydney Barnaby, and demonstrated the necessity for very wide blades, and a sufficiency of total area in the propellers of such vessels. It was also shown that propellers of relatively small diameter and high revolutions could be designed to approach very closely in efficiency to propellers of large diameter and normal revolutions. Further, the reconstruction of the turbines showed clearly the gain in weight and efficiency by subdividing the power over turbines in series on the steam on different shafts. The net results of these trials proved that turbine propelling machinery was more economical than reciprocating machinery for high-speed vessels.

Water Consumption per Hour at various Cruising Speeds.

		Lbs. per hour.
At 11 knots—	Velox, using piston engines exhausting into ordinary turbines	8,650
	Eden, using cruising turbines exhausting into ordinary turbines	16,146
	Piston-engined destroyer ...	14,892
At 13 knots—	Velox, using high-speed turbines only	24,375
	Eden, using cruising turbines exhausting into ordinary turbines	21,230
	Piston-engined destroyer ...	18,140
At 15 knots—	Velox, using high-speed turbines only	32,750
	Eden, using low-pressure cruising turbines exhausting into ordinary turbines	28,000
	Piston-engined destroyer ...	28.750
At 18 knots—	Eden, using low-pressure cruising turbine exhausting into high-speed turbines	41,050
	Piston-engined destroyer ...	45,645

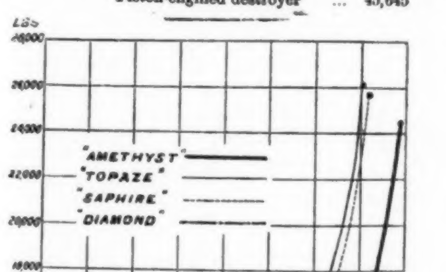


Fig. 1—Coal Consumption per Hour at Various Speeds.

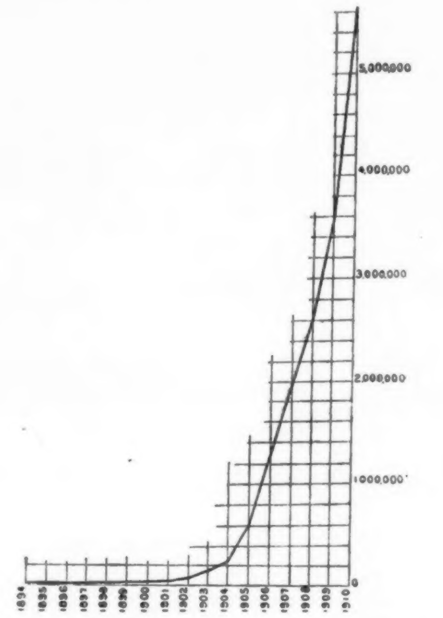


Fig. 2—Diagram Showing Total Horse-power of Parson's Steam-Turbines Applied to Marine Propulsion. Completed and Under Construction Each Year from 1894 to December, 1910.

At this stage the pioneer association was transferred to a new company, the Parsons Marine Steam-Turbine Company, Limited, for dealing with the system on commercial lines. The first order was in 1899 for a destroyer, the "Viper," from the British Admiralty, Sir William White being then Director of Naval Construction. The principal dimensions were the same as the 30-knot type of that period, but the speeds guaranteed were 31 knots ahead and half full-speed revolutions astern. Her maximum speed during a one hour's special trial, but with approximately full weights on board, was 36.5 knots, and under contract conditions of coal consumption was 33.38 knots. The economy in coal consumption at high speeds was good and she fulfilled in every respect the contract conditions, but the results of cruising speeds showed the desirability of modifications in the turbines in future designs to improve the economy at cruising speeds, and in all subsequent war vessels cruising turbines or cruising elements have been added at the high-pressure end of the turbine installation. In some very recent vessels impulse elements, in others geared high-pressure turbines, are being employed for the same purpose. At about the same time as the "Viper" was ordered, Messrs. Sir W. G. Armstrong, Whitworth, and Co., Limited, placed an order for the machinery of another destroyer, the "Cobra." The machinery of the "Cobra" was a duplicate of that fitted in the "Viper." The "Cobra," on a three hours' continuous run, maintained the mean speed of 34.6 knots.

It was very early realized that the suitability of the turbine for steam of very low pressure, which had been proved by the high percentage of power realized in the low-pressure portion of land turbines, would find an important application in ships by working the turbine from the exhaust of reciprocating engines, but not until 1901 was the first combination vessel, the "Velox," a 30-knot destroyer, laid down as a speculation by the Parsons Marine Steam-Turbine Company, Limited. Her main propelling machinery was nearly a duplicate of the "Viper's," but in order to increase the economy at speeds below 13 knots, two triple-expansion engines of 150 horse-power each were coupled to the low-pressure turbine shafts through flexible and detachable clutch-couplings. At low speeds the reciprocators exhausted into the high-pressure turbines; at speeds above 13 knots, the engines were uncoupled. The vessel was acquired by the Admiralty in 1903. The same year H.M.S. "Eden," of practically the same dimensions as the "Velox," was launched, and cruising turbines in series were fitted in her instead of reciprocating engines.

The Admiralty carried out a series of comparative trials at cruising speeds with the "Eden" and "Velox," and a sister vessel with reciprocating engines, of which the table Fig. 1 is a summary.

In 1902 the Admiralty placed the order for the third-class cruiser "Amethyst," with turbines, and for three sister vessels with reciprocating-engines of 10,000 horse-power. The turbine installation of the "Amethyst" was of the usual three-shaft arrangement, the high-pressure turbine driving the center propeller, and the two low-pressure turbines in parallel on the steam driving the wing propellers, a high-pressure cruising turbine and an intermediate-pressure cruising turbine being also directly coupled through flexible claw couplings to the low-pressure turbine shafts; these latter were in series on the steam with the main high-pressure turbine. The trials of these vessels conclusively proved the superiority of the turbine in water consumption (Fig. 1). At speeds of 15 knots, the water consumption of the turbine vessel was equal to that of the reciprocating vessels, and at higher speeds the superiority of the turbine was considerable, while at the designed speeds of 21¾ knots it reached 30 per cent, and at the maximum coal consumption allowed by the specification, the power developed as estimated from the curve of resistance of the vessel by the turbine vessel exceeded the power developed by the reciprocating vessel by 42 per cent. The maximum speed attained by the "Amethyst" was 23.6 knots as against 22.3 knots for her sister ships. The increased efficiency derived from the cruising turbines was very marked at low speeds, at some speeds 20 per cent of the total power being developed by them.

Subsequent to the official trials, arrangements were made for utilizing the auxiliary exhaust in the turbines, when a further increase in economy was obtained.

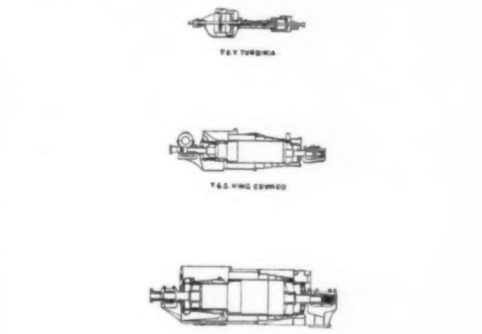


Fig. 3—Diagram Showing the Progressive Increase in the Size of Marine Turbines.

The comparative trials of these vessels had a great influence upon the future of the turbine.

As a general rule, the larger and faster the vessel, the more easy it had been to arrive at a satisfactory and profitable all-turbine solution as regards efficiency and first cost. Below the sea speed of 16 knots, the solution is not altogether favorable, and very few such vessels have been fitted. A slight lowering of the boundary of suitable speed exists in very large vessels, and also may be

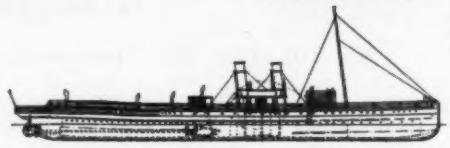
* Paper read at the Jubilee Meetings of the Institution of Naval Architects, July 5, 1911.

† "The Steam-Turbine and its Application to the Propulsion of Vessels," by the Hon. C. A. Parsons. Read before the Institution of Naval Architects, June, 1903.

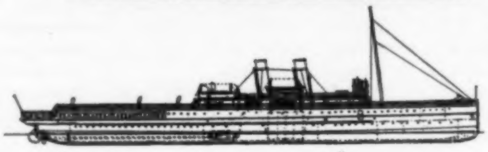
THE MARINE STEAM-TURBINE FROM 1894 TO 1910.

"Turbinia:" built 1894; length, 100 ft.; displacement, 44½ tons; horse-power, 2300; speed, 32¾ knots.

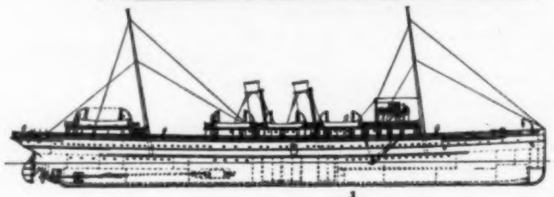
"King Edward:" built 1901; length, 250 ft.; displacement, 650 tons; shaft horse-power (estimated), 3500; speed, 20.48 knots.



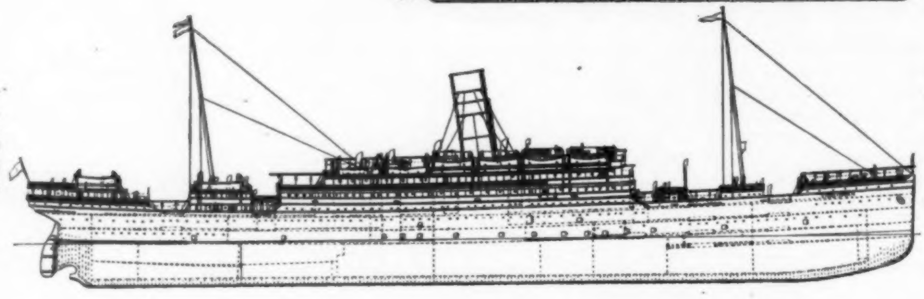
"Queen Alexandra:" built 1902; length, 270 ft.; displacement, 750 tons; shaft horse-power (estimated), 4000; speed, 21.625 knots.

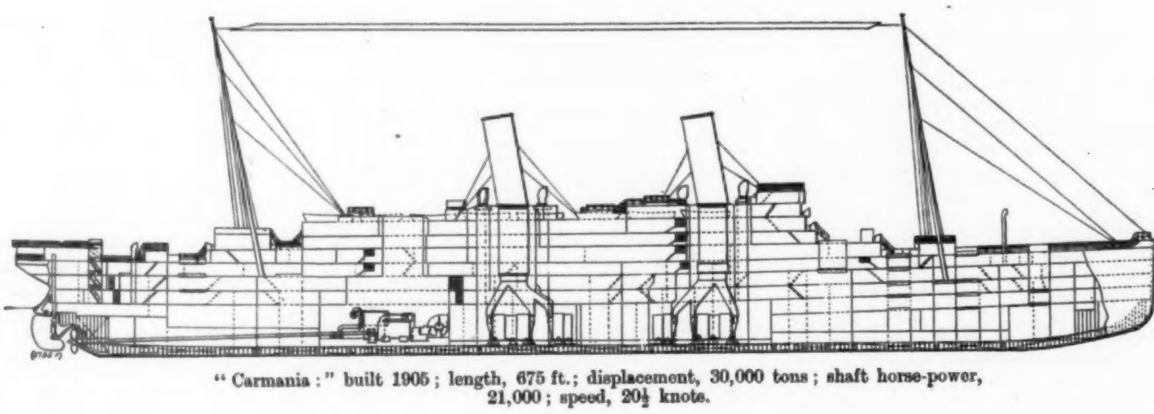


"The Queen:" built 1903; length, 310 ft.; speed, 21.76 knots.

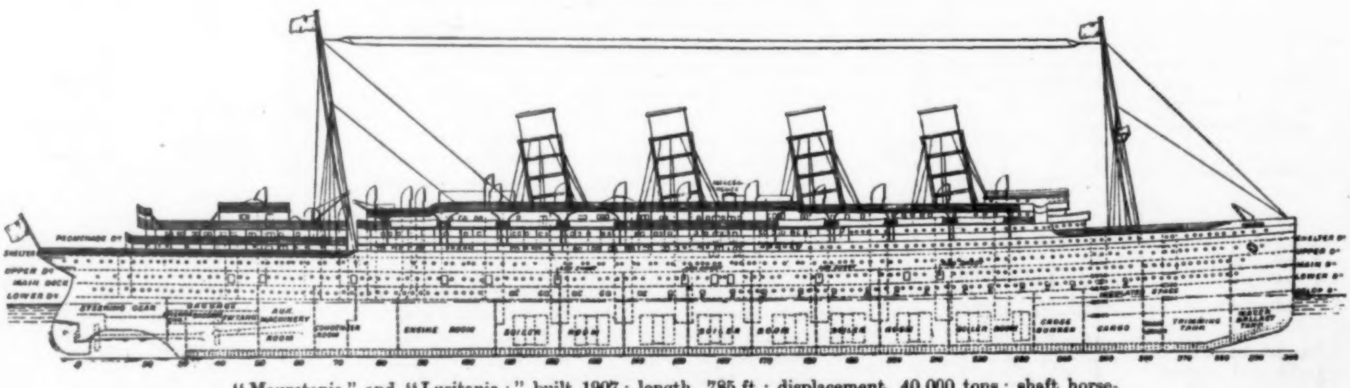


"Virginian," built 1905; length, 530 ft.; displacement, 13,000 tons; estimated shaft horse-power, 12,000; speed, 19.1 knots.





"Carmania:" built 1905; length, 675 ft.; displacement, 30,000 tons; shaft horse-power, 21,000; speed, 20½ knots.



"Mauretania" and "Lusitania:" built 1907; length, 785 ft.; displacement, 40,000 tons; shaft horse-power, 74,000; speed, 26 knots.

FIG. 4—DIAGRAM SHOWING GROWTH IN SIZE OF TURBINE-PROPELLED MERCHANT SHIPS.

effected by the employment of the impulse principle at the high-pressure end, as more fully explained later.

This most important question of applying the turbine to lower-speed vessels has from the commencement received consideration, and one satisfactory solution appeared to lie in the combination system to which we shall further allude later. Another solution with a somewhat different scope has more recently been investigated; it is the use of double helical gearing of the De Laval class on a large scale for gearing the high-pressure portion only, or in some cases the whole of the turbines onto the screw shafting. Both of these solutions have given satisfactory results, but the reduction gearing appears to be the more important as applicable to vessels of all speeds. Both systems are described more fully later.

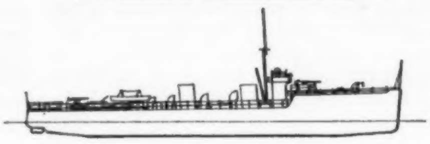
The first turbine battleship "Dreadnought" was laid down at Portsmouth in October, 1905. The primary contract for the whole of the machinery was placed with Vickers Sons and Maxim, Limited, the Parsons Marine Steam-Turbine Company, Limited, being sub-contractors for the turbines. She has four shafts, two high-pressure and two low-pressure turbines, and two cruising turbines are coupled to the low-pressure turbine shafts. The astern turbines consist of a high-pressure astern portion in a separate casing on the high-pressure ahead shaft, in series with a low-pressure astern portion incorporated in the main low-pressure-turbine casing. The cruising turbines are in parallel, and not in series, on the steam as in the "Amethyst"; the high-pressure, low-pressure, cruising, and astern turbines comprise one propelling unit on each side of the vessel.

We may quote a summary of the advantages of the system, the reasons given by the First Lord of the British Admiralty for the adoption of the Parsons turbine in the "Dreadnought" and succeeding ships as determined by a committee on naval design: "The question of the best type of propelling machinery to be fitted was most thoroughly considered. While recognizing that the steam-turbine system of propulsion has, at present, some disadvantages, yet it was determined to adopt it because of the saving in weight and reduction in number of working parts, and reduced liability to breakdown, its smooth working, ease of manipulation, saving in coal consumption at high powers, and hence boiler-room space, and saving in engine-room complement; and also because of the increased protection provided for with this system, due to engines being lower in the ship—advantages which more than counterbalance the disadvantages. There was no difficulty in arriving at a decision to adopt turbine propulsion from the point of view of sea-going speed only. The point that chiefly occupied the committee was the question of providing sufficient stopping and turning power for purposes of quick and easy maneuvering. Trials were carried out between the sister vessels "Eden" and "Waveney," and the "Amethyst" and "Sapphire," one of each class fitted with reciprocating and the other with turbine engines; experiments were also carried out at the Admiralty experimental works at Haslar, and it was

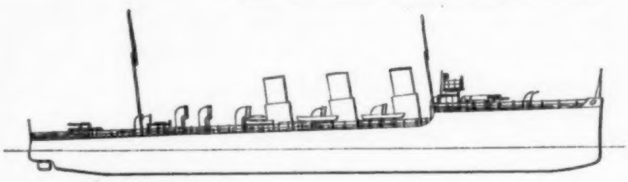
"Turbinia:" built 1894; length, 100 ft.; displacement, 44½ tons; horse-power, 2300; speed, 32¾ knots.

H.M. torpedo-boat destroyer "Velox:" built 1902; length, 210 ft.; displacement, 420 tons; shaft horse-power, 8000; speed, 27.12 knots.

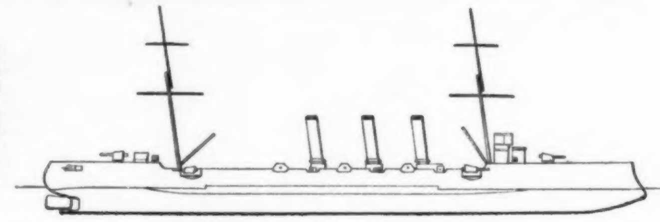
H.M. torpedo-boat destroyer "Eden:" built 1903; length, 220 ft.; displacement, 540 tons; shaft horse-power, 7000; speed, 26 22 knots.

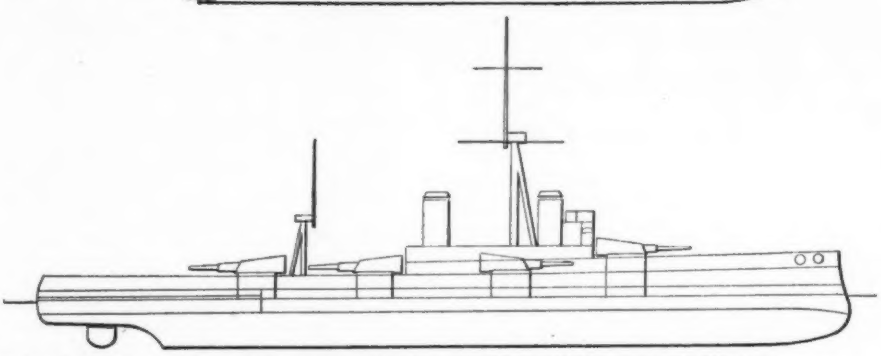


H.M. torpedo-boat destroyer "Swift:" built 1908; length, 345 ft.; displacement, 2170 tons; shaft horse-power, 35,000; speed, 35.3 knots.

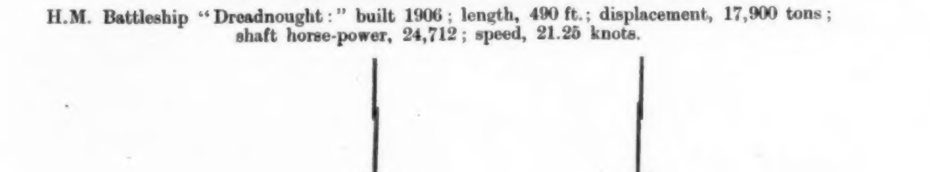


H.M. 3rd-class cruiser "Amethyst:" built 1905; length, 360 ft.; displacement, 3000 tons; shaft horse-power (estimated), 14,200; speed, 23.63 knots.





H.M. Battleship "Dreadnought:" built 1906; length, 490 ft.; displacement, 17,900 tons; shaft horse-power, 24,712; speed, 21.25 knots.



H.M. Armoured Cruiser "Invincible:" built 1908; length, 530 ft.; displacement, 17,250 tons; shaft horse-power, 42,000; speed, 26 knots.

Fig. 5—GROWTH OF TURBINE-PROPELLED WARSHIPS FROM 1894 TO 1908.

considered that all requirements promise to be fully met by the adoption of suitable turbine machinery, and that the maneuvering capabilities of the ship when in company of a fleet, or when working in narrow waters, will be quite satisfactory."

Sir Henry Oram, the Engineer-in-Chief of the Fleet, in his address as President of the Junior Institution of Engineers, stated that at full power the steam consumption of the "Dreadnought" was 13.48 lb. per shaft horse-power per hour, while in the succeeding battleships of the class it averaged 13.01 lb., and in the three cruisers of the "Invincible" class, 12.03 lb. With reciprocating engines, nearly 16 lb. would be a fair average, and it thus follows that a great reduction in boiler weights was permissible. Again the high efficiency of the low-pressure turbine made it well worth while to pass the exhaust steam from the auxiliary engines to this turbine instead of to the condenser. Indeed, the exhaust steam in some battleships has been proved to be alone sufficient to drive the vessel at a speed of 5 to 6 knots.

The coal consumption at full power of the three 26-knot armored cruisers of the "Invincible" class ranged from 1.2 lb. to 1.7 lb. per shaft horse-power per hour, the average for the three ships being 1.47 lb. per shaft horse-power. In the three cruisers of the "Minotaur" class, with piston engines, it was 1.8 lb., and in the six cruisers of the "Duke of Edinburgh" or "Warrior" class 2.1 lb. per indicated horse-power per hour. On the thirty hours' endurance trial at 70 per cent of the total power, the turbines also proved more efficient, although the advantage was not so marked. At one-fifth power the coal consumption of the three "Invincible" cruisers averaged 2.4 lb. per shaft horse-power per hour, as compared with 1.87 lb. per indicated horse-power per hour in the "Minotaurs" and 2.05 lb. in the "Duke of Edinburgh" cruisers.

In the mercantile marine the first vessel to be fitted with turbines was the Clyde passenger steamer, "King Edward," built to the joint ownership of Captain John Williamson, Messrs. Denny, of Dumbarton, and of the Parsons Marine Steam-Turbine Company, Limited. Her length is 250 ft., and, with 3,500 horse-power, she attained a speed of 20.48 knots. Her success led to the construction of a second vessel for the Clyde passenger traffic in 1903, and in the same year the "Queen" was built for the Dover and Calais route. All these vessels have three shafts, the high-pressure turbine in the center exhausting into two low-pressure turbines on the wing shafts. Thus, by 1904, two of the most suitable fields for the marine turbine had been entered, namely, for vessels of war and cross-channel and passenger service, and, by 1905, the turbine was being adopted for nearly all new cross-channel steamers of high speed built in this country, and about a year later by the British Admiralty for all new construction.

The application to large liners remained as yet untouched. The first vessels to be fitted with turbines for transatlantic service were ordered by the Allen line, viz., the "Victorian" and "Virginian." This marked a notable step in advance in the application of the new system to ocean-going ships of high speed. At this juncture the late Lord Inverclyde appointed a commission of experts to investigate the suitability of the turbine for two express Cunarders for the New York route.

After most careful consideration of all data then available, and in view of much additional experimental research conducted by the committee, as well as tests on large land turbines, and on existing turbine vessels, the committee unanimously recommended turbines in preference to reciprocating engines for the "Mauretania" and "Lusitania" of 70,000 horse-power and 24½ knots sea speed. The performance of these vessels has justified the decision; a mean speed of 26 knots has been maintained in favorable weather across the Atlantic, and an average speed of 25½ knots has been maintained on many successive voyages. This step completed the entry of the turbine into all classes of fast vessels for which it was at the time deemed suitable, and its adoption for fast vessels has since been almost universal.

In 1904 the general policy of granting licenses on easy terms was decided upon by the Parsons Marine Steam Turbine Company, and by the end of 1905 a large number of shipbuilding and engineering firms had acquired marine licenses, the number having considerably increased up to the end of 1910. It is now clear that the broad policy then adopted has been conducive to the exceptionally rapid adoption of the turbine. Turbines of the Parsons type are now being built in the principal engineering works of France, Germany, Austria, Italy, Russia, Spain, Belgium, Sweden, and Denmark, as well as in Japan and the United States of America. The curve of horse-power (Fig. 2) completed and on order each year up to the end of 1910 shows the development which has taken place since the introduction.

Since the construction of the turbines of the "Turbinia" in 1897, which were in series on the steam and on three shafts, there has been no very notable increase in economy in steam per shaft horse-power, excepting that due to size and consequent reduction of leakage and steam friction losses, the reason being that the turbines of the "Turbinia" were designed with as high a velocity ratio as has been found compatible with weight and space, and that her condensers were of ample size.

In marine turbine design the chief governing factors are weight and cost dependent on a limited surface speed of turbine, which is governed by the maximum speed of revolution allowed by the propeller, and from the commencement a judicious compromise has been arrived at between turbine and propeller. Such limitations will, however, be materially reduced, should geared turbines come into use, and higher coefficients of turbine efficiency would then become possible and compatible with moderate first cost and weight; the question of propeller efficiency would be more easily dealt with, and the gain in total propulsive efficiency thereby would be substantial.

To be continued.

The Radioactivity of Human Organs.

THE tests of R. Werner and others have proved that ordinary physical bodies have an effect on photographic plates. As it was suspected that this might be due to radioactive action, Dr. Albert Caan of Heidelberg made extensive tests, investigating the radioactivity of the human organs, by means of the Bercker Emanometer.

This instrument gives account of every emanation and radioactive action, and consists in the main of a shaking tank and an electric measuring instrument connected with each other by a rubber tube and electric wires. The measuring instrument is a Wulf wire electrometer connected to a 200-volt storage battery, and a powerful microscope through which readings are taken. Dr. Caan examined forty-one different organs, coming from twelve different persons, reducing about 100 grains of each organ to ashes, and placing it into the manometer. In every case he found the presence of a substance, which made the air electrically conductive. Whether this substance is identical with Radium, cannot be said with certainty. But all indications point to the conclusion that the substance is radioactive. The activity of the brain is especially high, the heart and liver are less active, and the kidneys and spleen are almost entirely inactive; the lungs again show great activity.

Social position, calling, life, and the location from which individuals come have very little influence on the radioactivity of the organs. Increasing age increases the quantity of radioactive matter. Only a few cases have been investigated so far, to find what difference health or disease make in this connection, but it seems that diseased organs have a higher radioactivity.

As regards the origin of the radioactive substance seemingly present this might come from the food and drink or else from the air inspired. Both hypotheses could be harmonized with the phenomenon of increasing radioactive substance with growing age. No conclusion can as yet be reached as to the rôle of radioactive substances in the vital activity of the cells of the human body.—*Elektrotechnischer Anzeiger.*

The Nitrogen Cycle As It Affects Agriculture*

The Circulation of One of the Most Important Elements in Nature

By E. S. Holmes

The continued growth of plants and animals is dependent on many conditions, but one of the vital factors governing their development is the provision of nitrogen for their use in such a form as best suits the requirements of the several organisms. The important question of nitrogen supply for the use of growing crops on the farm is one that does not receive sufficient attention by the majority of agriculturists, and it is in this article proposed to endeavor, with the aid of a simple diagram illustrating the nitrogen cycle, to indicate the changes which nitrogenous compounds undergo under certain conditions, the natural process by which plants and animals obtain this absolutely necessary element for their growth, the losses which occur, and the best methods of conserving and adding to the nitrogen supplies of the farm.

As is well known, nitrogen constitutes roughly about three-quarters, by volume, of the atmosphere; but, being an inert gas, it does not readily enter into combination with other elements, and conversely, and for the same reason, it is easily liberated from compounds containing it. Hence, the ultimate tendency of nitrogen in combination is for it to be set free as gaseous nitrogen, in which form it is not readily available to ordinary plants and animal life.

Now we have the two important facts, that nitrogen is an extremely valuable plant food; and, at the same time, it is easily rendered unavailable so far as its usefulness as food to ordinary plants or animals is concerned. Recognizing both these facts, it becomes a question of no little moment to the farmer as to how he may best prevent the loss of an element in the absence of which his crops will not come to maturity; but, before considering how losses may best be prevented, we must first consider the changes which nitrogen compounds undergo in the nitrogen cycle, and the chief conditions which lead to the loss of this element.

NATURAL CHANGES.

On reference to the diagram, we may take, as a starting point, the nitrogenous vegetable compounds, that is, nitrogen contained as compounds in plants. When these are devoured by animals as food, they are converted, by digestion and change in the animal body, into nitrogenous animal compounds. Within the animal organism, continuous building up and breaking down of the tissues of the body is taking place, and in the latter process nitrogen becomes a waste product and is thrown out of the body in the liquid excrement in the form of urea.

This urea is an interesting compound from many points of view, but its chief interest to the farmer centers in the fact that it is very easily converted by certain bacteria and ferments into ammonia, and it is here that a great deal of the loss of nitrogen from farmyard manure occurs. The marked smell of ammonia noticed in an ill-ventilated stable is due to the decomposition of urea resulting in the formation of free ammonia, and this ammonia being volatile is practically lost to the farmer as a manure, as it becomes dissipated into the air and so is lost. Certain species of nitrifying bacteria, however, are capable under certain conditions, such as free æration, absence of light and presence of a slightly alkaline medium, of converting ammonia into nitrous acid which forms nitrites with such substance as lime present in the medium in which the bacteria are working.

Hence, if the manure containing the urea is properly looked after and subsequently applied to the soil, the nitrogen in the ammonia formed from the decomposition of the urea is fixed in the form of nitrites. These nitrites are not available to plants as food, but are converted by still other bacteria, working also under a certain set of conditions, into nitrates, and it is in this form that nitrogen is assimilated by plants. It must be remembered, however, that these changes from ammonia to nitrites, and nitrites to nitrates, take place to the fullest extent only under favorable conditions, and if the soil be water-logged, sour, and uncultivated, the reverse actions may be brought about by denitrifying bacteria, and the nitrogen will be lost.

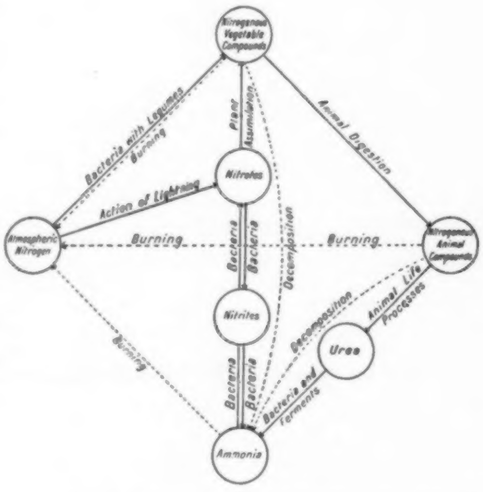
The nitrogen cycle does not of necessity include the stage through the animal kingdom, for nitrogenous vegetable matter decaying in the soil is acted on by the nitrifying bacteria. It is converted into nitrites, and later into nitrates, whence it is again available to plants, and the cycle completed. Another cycle is completed when the nitrogen, set free into the air when vegetable matter is burned, is returned to the vegetable kingdom again by that class of plants known as the legumes, which, acting in symbiosis with certain forms of bacteria, have the power of fixing atmospheric nitrogen for their own use as food.

HOW NITROGEN IS LOST.

As stated above, the burning of vegetable matter leads to the nitrogen contained in it being set free into the air, and the same result takes place from the combustion of animal matter, or when ammonia or its compounds are heated to a high temperature. It is to this practice of burning and the non-conservation of manures that the main loss of nitrogen that takes place on a farm, is due. For instance, when stubble is burned off, timber cleared and burnt, or vegetable or animal refuse destroyed by fire, nitrogen is set free into the air; and, when manures are allowed to lie and rot, or animal or vegetable matter allowed to decompose with free access of air and direct exposure to the weather, the most valuable constituent, i. e., the nitrogen, is lost in the ammonia formed during the decomposition process. It will be easily recognized that the amount of nitrogen dissipated into the air by the above actions is something considerable; and, if it were not for a provision of Nature, our soils would much sooner lose their fertility.

MEANS WHEREBY NITROGEN MAY BE REGAINED AND CONSERVED.

It has already been mentioned that Nature has endowed a certain class of plants with the ability to



In the above diagram, the arrows indicate the changes brought about by certain actions, *e.g.*, animal digestion converts nitrogenous vegetable compound into nitrogenous animal compounds. The dotted arrows indicate the actions which may result in the loss of nitrogen, either as free nitrogen or as ammonia.

THE NITROGEN CYCLE.

use atmospheric nitrogen for their requirements. It is almost entirely for this reason that the farmer, when he green-manures his land, chooses, wherever practicable, a leguminous (pod-bearing) plant for his purpose. He knows that in this way he has a cheap method of providing necessary food for other crops which have not been endowed with this power of supplying their requirements from the air. Another means whereby atmospheric nitrogen is fixed, is the formation of small quantities of nitric acid during the electric discharges of a thunderstorm. The acid so formed is washed down in the rain and readily becomes available to the plant. It is doubtful, however, whether the above two natural provisions account for the returning into combination of as large a quantity of nitrogen as is set free. In any case, the world at present depends for its supply of easily available nitrates mainly on the deposits in South America; and, for its ammonia supply, on the waste products of coal gas manufacture. The nitrate deposits in Chili must in time run out, and the demand at the present day for nitrates in the manufacture of explosives has put almost a prohibitive price on them as manure for crops, except perhaps where intense culture is carried on.

Many attempts have been made by chemists to fix atmospheric nitrogen for use as manure, and for manufacturing purposes; but, owing to its inert nature, fixation is very difficult, and scientific research has not so far led to the discovery of any cheap process. It would thus appear probable that the world would sooner or later be faced with a nitrogen famine if it were not for the consideration that scientists may be trusted to eventually devise some cheap means for the fixation of atmospheric nitrogen. Already considerable quantities of calcium nitrate and cyanamide are being made artificially by abstraction of the atmospheric nitrogen by means of electricity, and the resultant products have yielded satisfactory returns.

Nature always exacts some penalty for waste, and the agriculturist who wilfully neglects his nitrogen supplies will sooner or later find his land impoverished and himself involved in considerable financial outlay in bringing it back to fertility. His efforts in maintaining fertility should therefore be directed to the growing of leguminous green crops, either as fodder or as green manure, and to the careful conservation of his bulk manures. Farmyard manure, instead of being allowed to rot in the weather, should be pitted, and a small amount of some material, such as gypsum, added.

Special attention needs to be directed to the liquid excrements, as they are of much greater nitrogen value than the solids; and, if possible, they should be collected in a tank or other receptacle. If they are to be used immediately, dilution with an equal quantity of water is advisable and a little superphosphate may be added, as the urine of grass-eating animals is deficient in phosphates. It is advisable, however, to use some of the liquid excrements along with the solids in the rotting process in the pit. In fact, the whole may be used in this way if sufficient bulk material, such as straw, etc., be present.

In this way, large quantities of valuable manure may be prepared; and, as the value of the addition of farmyard manure to the majority of soils is well recognized, its utilization need not be further advocated here. What needs to be emphasized is the fact that valuable plant food is being continually lost from the majority of farms, mainly through neglect. If the farm is to be carried on as a business proposition, and to be worked in a business-like way, then the owner will have to do his best to see that these losses are reduced to a minimum.

* Reprinted from the *Journal of Agriculture, Victoria.*

The Telemicro-phonograph

The instrument named the telemicro-phonograph described as a combination of a microphone and a phonograph, serves the purpose of transmitting phonographic records. "What the telephone does for ordinary conversation," says *Prometheus*, "the new apparatus performs with the record of a talking machine. In other words, by its aid musical and speech records can be transmitted to any distance, and if desired, to several points at once. In addition to this, the sound is much increased in body, while all secondary noises, such as the scratching which so mars the usual phonograph performance, are almost completely eliminated.

"The apparatus comprises a microphone of the form used on French war vessels for transmitting orders to the engines, the guns and other posts. This microphone will withstand currents of considerable intensity, and can therefore be made to operate the diaphragm of telephone receivers capable of loud reproduction.

It is mounted upon a talking machine, and receives the sound waves produced in the usual way by a style and diaphragm. These sound waves are transformed into telephone currents and thus transmitted in the usual way. The diaphragm is of the usual kind employed on phonographs. Since the microphone and the diaphragm are independent of one another, each can be regulated separately, and thus the best possible conditions for the perfect working of the apparatus are secured. The reproduction in the telephone varies in loudness according to the strength of the current used in the circuit.

"The telephone receiver, which is of the loud-speaking type, is built on the Ducretet system. The distance between the vibrating diaphragm and the pole face of the electro-magnet can be regulated micrometrically. The current required to actuate this apparatus is furnished either from a primary battery or from a number of secondary cells. The current intensity (and with it the loudness) is regulated by means of a switch key."

The Potash Supply

The Search for Domestic Sources

The question of the potash supply has been receiving considerable attention quite recently, and, in view of the importance of the subject, we take occasion to reproduce here from two or three sources some seasonable comments and reports on the situation.

We quote first W. D. Richardson, writing in the *Journal of Industrial and Engineering Chemistry:*

"There will always be a 'potash situation' and the possibility of a controversy so long as the world's supply of potash happens to be lodged in one country and is controlled by a monopolistic combine of which the government of the country in question through its ownership of mines is a part. At the bottom of the recent and present controversy between the American consumers of potash and the German producers stands the fundamental fact that we are forced to buy our potash of Germany because there is no other source of supply. Germany can charge all that the trade will stand for her potash, in defiance of any natural laws of supply and demand and Americans will have to pay the price.

"The general situation has changed but little during the year, and indeed not much change was expected after the failure of our government to reach a successful conclusion in its diplomatic negotiations. The American contractors, who arranged for the delivery of their requirements through an American concern which had in turn contracted with the independent mines, are paying syndicate prices for their deliveries, although the money is paid under protest on account of the sur-tax, and it is possible that some settlement will later be arrived at.

"The great hope of American consumers lies in the discovery of adequate potash deposits in the United States. The government has wisely appropriated a sum of money, for the purpose of prospecting and investigating probable sources of supply. Recently announcement has been made by the Secretary of Agriculture that potash has been discovered in the West in large quantities, but details are withheld until the assembling of the next Congress, when they will be communicated to the legislative committees which have the matter in charge. It is to be hoped that this important announcement will be fully supported by the facts when they are made known and that the deposits will prove commercially available in the near future. No other influence, it would seem, can change the monopolistic German attitude.

"The German Syndicate is already greatly interested in Secretary Wilson's announcement, and it has been pointed out in the newspapers that even if potash were obtainable in the Western States, it could not compete with German potash on account of high freight rates. Statements have also been made to the effect that before the Syndicate was formed, an examination was made of possible American potash deposits, and the conclusion was reached that America possessed no deposits large enough to be worked at a profit.

"Feldspar and other potash silicates as sources of soluble potash do not appear to be arousing interest in the fertilizer trade or chemical manufacture. The processes which have been proposed—fusion with common salt or with salt and lime, electrolysis, etc.—do not give promise of profitable working. The proposition is a very low-grade one at best. The best potash silicates carry only 12 to 14 per cent of actual K_2O, and with the addition of fluxes these percentages would be still further reduced. Lixiviation and concentration would probably prove far too expensive, considering the price of the finished product. Soluble potash from insoluble silicates does not appear to be in the realm of the possible at the present time.

"The only hope lies in the discovery of soluble sources of supply, and it is for this reason that the fertilizer and chemical manufacturers as well as the general public are awaiting with the greatest interest further announcements from the Department of Agriculture."

A short anonymous note appears in the same issue of the journal cited, drawing attention to the efforts of the United States Geological Survey to discover any possible sources of potash salts in the United States:

INVESTIGATION OF POTASH DEPOSITS.

"An investigation into possible sources of potash salts in the United States is being made this year by the United States Geological Survey, and as a part of this work the Survey will soon fit up a temporary laboratory at Fallon, Nevada, for the purpose of testing samples of salines from the Great Basin or desert areas.

"Samples of such alkaline salts will be tested at this laboratory free of charge if a definite statement of the locality from which they were obtained be sent with the samples. The location should be given by section, township, and range, if possible, otherwise by distance and direction from the nearest post-office or settlement. Samples should be addressed to Hoyt S. Gale, United States Geological Survey, Fallon, Nev. Upon receipt of a request small sample sacks for sending the material by mail will be forwarded from the above address.

"If so requested at the time that a sample is submitted for test, the accompanying information concerning the locality of the deposit will be treated as confidential; and the evidence thus obtained is not to be used for the purpose of making land withdrawals."

Finally, we reproduce a note published in the *Press Bulletin* of the Geological Survey, on the nature and purpose of the work carried on under its auspices, more especially in Nevada.

THE SEARCH FOR POTASH.

The United States Geological Survey has just issued a short report, by Hoyt S. Gale, on the progress of the work of deep drilling for potash which is being carried on in Carson Sink, Nevada, near the town of Fallon. While no discovery of potash salts is announced by the Survey, Mr. Gale's report is a distinct and valuable contribution to the discussion of potash, setting forth clearly the broad, basic reasons which lead the geologists to the belief that they will find, sooner or later, in some one of these desert basins commercial deposits of soluble potash such as constitute the great Stassfurt beds in Germany.

Last winter Congress appropriated $20,000 to enable the Geological Survey to prosecute a search for potash, the money becoming available July 1. An appropriation of $12,500 was also made to the Bureau of Soils for a like purpose, and it was mutually agreed that the two appropriations should be administered in the spirit of co-operation, with an avoidance of duplication in work and territory.

FIVE SOURCES OF POTASH.

In a summary of the occurrence of potash in the United States, published by the Survey last winter, five general sources were mentioned—(1) igneous rocks, (2) marls, (3) alunite, (4) salines, and (5) organic sources, including wood ashes, beet-sugar molasses and residue, wool scourings, and seaweed or kelp. The Geological Survey has confined its activities to work on mineral saline deposits and is devoting a large part of its appropriation to the project of drilling for possible deposits of buried salts.

WYOMING'S POSSIBILITIES.

The first field work under the new appropriation was done in southern Wyoming, in the geologic formations termed the "Red Beds," which are known to be rich in salines, suggesting for many reasons the possibility of carrying deposits of the Stassfurt type. A considerable amount of study had already been devoted to this area and accordingly the data relating to the Wyoming salines were collected and reviewed and this work was followed by field examinations. These investigations indicated that the assumption of the existence of beds of potash salts in the Laramie Basin in southern Wyoming is logical, but the data at hand, which were fairly complete, proved to be chiefly of negative character so far as revealing any unusual amounts of potash is concerned.

REALIZING ON EARLY SURVEY WORK.

Extension of the study of the Great Basin desert region revealed this as the most promising area for the Survey's first drilling operations. This conclusion was based largely on the early geologic work of G. K. Gilbert and I. C. Russell, who, in Survey Monographs I and XI, describe in scientific detail the prehistoric Lakes Bonneville and Lahontan. These ancient lakes were, in a former geologic age, enormous bodies of water, many times the area of Lake Superior, and Mr. Gale states that no more convincing reason can be advanced for the belief that immense quantities of saline material must be included in the strata underlying the desert sinks of the Great Basin than that set forth in the philosophic writings of these eminent geologists. His report contains direct quotations from these monographs, describing in detail the origin and structure of the old lake beds, and he adds that there exists in these treatises, representing field investigations in the early eighties, a wealth of maturely digested data on which to base the proposed plan of operation in 1911. From the study of these reports with their excellent maps it was concluded that the most promising test of the hypothesis of possible buried salines in concentrated form would be somewhere in the low portions of either the Lahontan or the Bonneville basin. The Lahontan basin was chosen because that lake is known to have never overflowed.

DRILLING IN NEVADA.

A drilling outfit having been shipped from Pittsburgh, operations were begun on October 1st with a 12-inch drill hole and the site was named the Timber Lake Well. The report gives the log of the well, which on November 18th had reached the depth of 319 feet. Evidence of the geologic period of desiccation in the form of crystallized beds of saline material has not yet been found in the strata penetrated, but it is expected that the drilling will be continued until at least a depth of 1,000 feet is reached.

The discovery of such saline deposits, though its likelihood is supported by the best geologic information of to-day, says Mr. Gale, should perhaps be regarded as a possibility rather than a probability. Inquiries are being received asking for an estimate of the probabilities of success in such an enterprise, with special reference to private undertakings based on the same plans. This, according to Mr. Gale, is a matter of judgment and each inquirer is left to draw his own conclusions from the facts presented in the report of the Survey's progress. The value of this possibility has, of course, been carefully considered and it is believed that as a public enterprise, at least, a reasonable test is not only justified but highly desirable. The report also contains information with reference to the collection and tests of potash samples being carried on in co-operation between the United States Geological Survey, the Bureau of Soils, and the department of geology of the Mackay School of Mines in Nevada, as well as an account of the activities of private enterprises in the search for potash.

A copy of Mr. Gale's report may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

A Throttling Two-Cycle Motor

The Simplicity of This Type Commends it for Automobile Construction

By C. Francis Jenkins

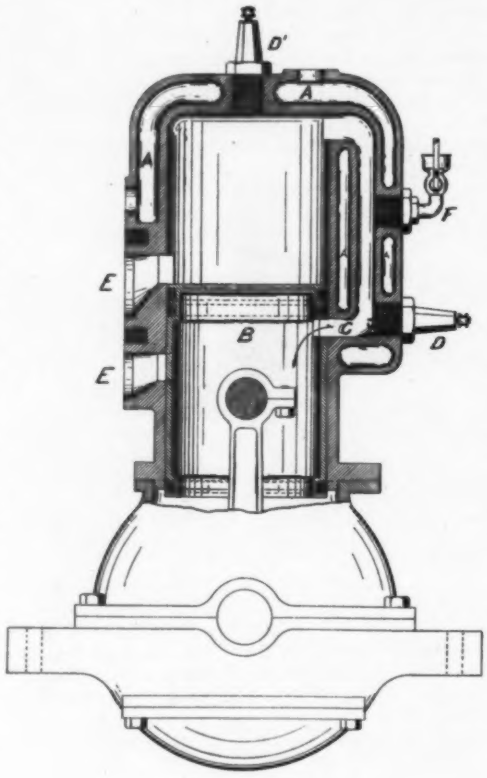
Because of its simplicity and lack of delicate parts, the two-cycle gasoline motor would be ideal for automobiles, especially for commercial trucks, if it could be throttled down until it turned over slowly and exploded evenly under light load and running idle.

As at present designed the two-cycle motor is notoriously wasteful of gasoline in automobile use on the average road surface. This comes about not because the motor is not as efficient at hard work as the four-cycle motor, but principally because, unless the motor is working at near its maximum capacity, there is too large a proportion of the carbureted charge mixed with the burned gas of the previous explosion. Fully nine-tenths of all automobile work is done at a rate much below twenty-five per cent of the maximum power of the motor, that is, the motor is working under throttled charge the greater part of the time. This means that much of the good gas is so mixed with the bad gas at the point of highest compression that considerable of the gasoline vapor is never burned at all. Beside the waste of gasoline, it is noticeable in the bad-smelling exhaust. In many comparisons of the two-cycle with the four-cycle motor under like conditions this loss has been found to average about twenty to ten in favor of the four-cycle motor, that is, a four-cycle motor will work a given weight of car twenty miles per gallon of gasoline, while the two-cycle motor under the same conditions will only make ten miles to the gallon. This is accounted for in several minor ways but the principal advantage the four-

cycle motor has over the two-cycle lies in the fact that the spark-plug is located at the gas inlet and in such manner that it fires small charges as efficiently as large charges, or practically so. This is not true in the usual construction of the two-cycle motor for the reason that the spark-plug is located at a point the farthest removed from the gas inlet. If, however, the spark-plug could be as advantageously located in a two-cycle motor as in the construction shown by the best practice in four-cycle motors there should be a corresponding efficiency. This efficiency would come about also because the spark could be advanced to its most advantageous position while the charge could be reduced to the least possible amount necessary to keep the motor turning. Obviously less heat would be wasted in the cooling jacket especially when running idle. No two-cycle engine, as at present constructed, will run idle without missing, while the four-cycle has been so developed and perfected that it not only runs idle without missing, but so slowly and quietly as to be practically noiseless. The trouble is that the small charges in the two-cycle motor will not fire because they are so mixed with the bad gas of the previous explosion. Necessarily the charge must be increased until there is a preponderance of good gas and the speed of the car controlled to such an extent as may be possible by retarding the spark, slipping the clutch, applying the brake, etc. As is well known to gasoline motor engineers, economy and efficiency are obtained by an advanced spark and a throttled charge. This has, up to the present time, in two-cycle motors, been an impossibility, principally because, as stated above, the spark-plug is placed at the most remote position, instead of being placed so that it sparks in a charge of good gas no matter how small the charge. If the firing begins in good gas then practically all the gas is converted into power, while if the spark occurs in a poor mixture, the mixture is fired with difficulty and often not at all until enriched by the second charge.

From the very earliest conception of the two-cycle motor to the present time no marked improvement has been made in it. And yet it would not appear to be an impossibility to accomplish the two things necessary to make it a successful competitor of its four-cycle brother, i. e., (*a*) keep the good gas segregated from the burned gas of the previous explosion, and (*b*) so place the spark-plug that it is always in this good gas no matter how small the charge is.

Such a construction is shown in the illustration and incorporates the desirable features of a four-cycle motor, that is, economy of gas with silent running and even explosions while running idle or at light work, while at the same time retaining all the features of simplicity of construction, easy cooling, etc., of the ordinary two-cycle motor. Heretofore when this desirable end was sought to be accomplished, baffle-plates, pockets, or other confining and irregular shapes were employed on top of the cylinder (usually), and these, getting red hot by the enveloping flame of the explosion, ignited the gas as it entered, and before the spark-plug got a chance to fire the charge, thus creating back-pressure, loss of power, an excessively hot engine, etc., defeating the very end sought.



Throttling Two-Cycle Motor.

A, Water Jacket; *B*, Trunk Piston; *C*, Gas Inlet to Spark Plug; *D'*, Supplementary Spark Plug; *E*, Exhaust; *F*, Oil or Priming Cup.

In the construction shown in the present invention the spark-plug is placed at the point of ingress of the gas, and in a confined passage, and overheating prevented by having this narrow passage water-jacketed.

The operation of the motor is as follows: Carbureted gas is drawn into crank-case from the carbureter (not shown) in the usual manner, i. e., by the upward movement of the piston; and by its downward movement is forced through the rectangular port in the wall of the piston into the combustion passage within the water-jacket when the port in the piston wall registers with the lower end of this combustion passage, and drives ahead of it the bad gas remaining after the previous explosion. If the throttle is wide open the combustion space above the piston will be completely filled, and on the ignition of the charge the maximum pressure will be exerted on the piston. If, however, the throttle is but slightly open, the combustion passage only may be filled and none overflow into the combustion space above the piston. This small charge will be just as efficient in proportion to its volume as was the larger charge, for it was compressed to practically the same extent and none was mixed with the bad gas of the previous explosion. It will, therefore, be obvious that the spark-plug is always swept by the fresh charge, be it large or small, and the ignition will be just as certain in one case as in the other, although the charge and consequent impulse may be only just sufficient to keep the engine turning over, and without missing a single explosion.

In the motor built to test and demonstrate this design, provision was made for a second spark-plug to be located in the top of the cylinder for speed work, if this was found necessary. No opportunity has yet been had for making track tests, though without regret, as this two-cycle motor will run idle without missing or "stuttering," which was the thing heretofore impossible.

Automatic Signaling Apparatus for Airships

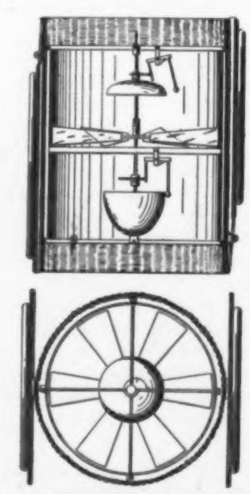
An Instrument That Appraises the Aeronauts of Changes in Altitude

By Our Berlin Correspondent

ENJOYABLE as an airship trip is to the passengers it is bound to put the nerves of the aeronaut to a strain sometimes excessive. The multiple duties incumbent upon him impel the direction of his mind at the same time to the many different instruments of the balloon, while the necessity of taking records frequently leaves hardly time enough to pay any attention to the country traversed or to the maps so indispensable for steering the course of the vessel. The most troublesome part of the task, however, is the necessity of continually examining the vertical motion of the ballon, by reading such instruments as barographs, anemometers, anemoscopes, etc., which in critical moments are apt so completely to absorb the attention of the aeronaut as to give rise to dangerous situations.

The instrument recently invented by Philipp Lentz of Gross-Lichterfelde will therefore be appreciated by all those interested in the progress of aeronautics and aviation. In fact, the "Kodophone," as it is termed, greatly relieves the strain on the eyes, by transmitting to the ears the most trying part of vision duties.

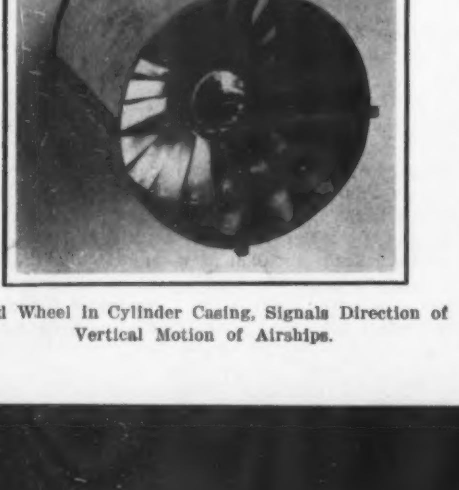
This instrument comprises a wind wheel, located horizontally in a metal cylinder within a protective basket of wicker work which, in accordance with such variations in air pressure as correspond to the rising and falling of the balloon, will signal the direction of vertical motion, by sounding one or other of two bells tuned to different notes. The experienced ear of the aeronaut readily infers the speed of rising or falling from the rate at which the bell strokes follow up one another: If both bells are silent, he is able to tell with absolute certainty that the balloon or airship is soaring in a horizontal direction.


Section and Plan View Showing Details of Signaling Apparatus.

The kodophone thus endows the aeronaut with a feeling of increased safety. Not only is he saved the trouble of continually consulting the barograph, anemometer or anemoscope, but the bells of the apparatus instantaneously signal the beginning of the upward or downward motion, whereas any other instrument only tells that the balloon *has* fallen. This is of enormous importance by night when the necessity of lighting the instruments makes the work of the aeronaut especially troublesome.

After simply attaching the protective basket to the balloon ring, the instrument is ready for immediate operation. In order that it may be used also on moter-propelled airships, the metal cylinder inclosing the wheel is covered at the top and bottom with wire gauze, which deviates any horizontal air currents from above and below the apparatus.

It will be readily understood that the aeronaut informed by the bell signal will be able, without losing any time, to take such measures as circumstances demand, thus saving both gas and ballast and accordingly increasing the range of the balloon.


Wind Wheel in Cylinder Casing, Signals Direction of Vertical Motion of Airships.


Basket Attachment to Airship Holds Automatic Signaling Device.

The Manufacture and Performance of the Edison Storage Battery*

By Howard Lyon

FIFTY years ago Plante demonstrated the possibility of using an electric current to do chemical work on plates immersed in an electrolyte and of obtaining a current again through reversal of the chemical process by connecting the plates to a conductor outside of the container. Such a cell behaves exactly as though it were some sort of a structure in which electricity could be stored as a reagent in a bottle, and thus it has become generally known as a storage battery. Until a very few years ago there had been no radical departure as to the nature of the plates and the electrolyte from the fundamental form assembled by Plante. The modern practical battery has continued to make use of lead plates and a sulphuric acid electrolyte.

The lead battery as developed since the time of Plante is open to serious objections, chief of which are the following: *First*—Lead structures, by reason of bulk necessary for strength and a heavy electrolyte make the weight of the battery excessive. *Second.*—The electrolyte (sulphuric acid) is intensely corrosive, and the nature of the liquid compels confinement in a fragile container. *Third.*—Physically the lead structures are weak and the pockets of lead oxide are weaker still. *Fourth.*—Secondary chemical activity is set up in a lead cell while standing partly discharged producing sulphate of lead instead of the useful oxides, so that in idleness there is a marked loss of electrical energy. *Fifth.*—The specific gravity of a troublesome electrolyte should be definitely maintained and the electrolyte should be rather frequently renewed. As a matter of fact the specific gravity of the electrolyte is constantly changing in the cycle of charge and discharge. *Sixth.*—Charging current exceeding a certain rather low amperage causes "buckling" of the plates. This loosens the oxide from the pockets and thus lessens the ampere capacity of the cell besides tending to produce short circuits. *Seventh.*—Such cells even in idleness must be charged at frequent intervals, for a discharged or partly discharged cell disintegrates rapidly.

Realizing the very great importance of the storage cell in modern electrical development and also the imperfections of existing types of batteries, Mr. Edison, about ten years ago, set himself to the task of producing a storage cell in which if possible the defects noted above might be eliminated.

Stated briefly the Edison Storage Cell makes use of steel grids holding perforated tubes containing nickel oxide and nickel flake for the positive plates and perforated box-like cases containing iron oxide for the negative plates, the plates being immersed in a solution of caustic potash containing a small per cent of lithium hydrate inclosed in a steel can. All the steel parts are protected by a specially durable nickel plate.

Commercial use of the later forms of the alkaline battery has abundantly demonstrated its practical efficiency for pleasure vehicles, trucks, and even omnibuses and cars. Chemical and structural durability is a phase of large significance as applied to this new energy-storing device. Durability and dependability are far more important qualities from the standpoint of the users of a storage battery than weight, cost, or efficiency, however desirable these latter qualities may be. *The truckman needs power, not efficiency curves.* Durability is insured by the mechanical construction of the Edison battery and by an electrolyte and active materials which remain unchanged with very moderate care. Dependability follows from the fact that in commercial service such treatment as a battery ordinarily receives will not change the nature or behavior of plates or electrolyte. The confidence of the manufacturers of the Edison battery is expressed by their guarantee that the capacity of the battery will not be less than 90 per cent of the original capacity after three years of service when applied to commercial vehicles.

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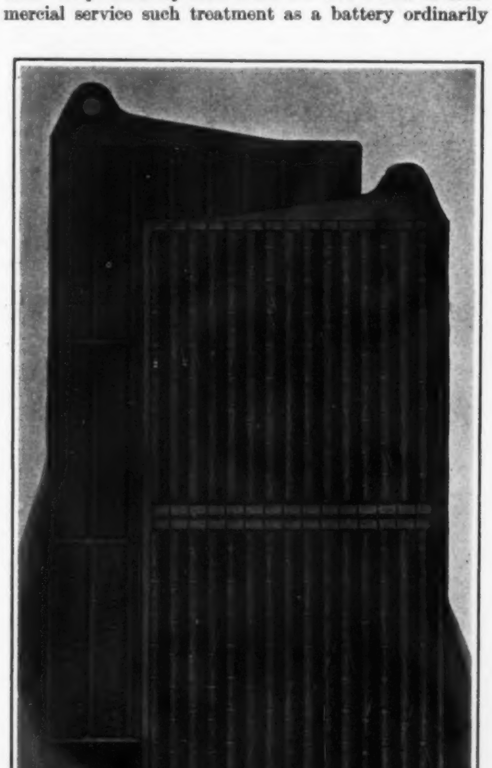


Fig. 1.

Commercial service inevitably means a likelihood of overcharge and discharge, and lack of attention to the electrolyte. This neglect in the Edison battery results merely in less immediate capacity, not in ruination of the cells.

Mechanically the cells are as stable as a well-made gas-cock. In fact they are so well made that the plates are confined in a container whose cover is welded in and all but hermetically sealed.

With renewal of electrolyte after each 250 complete charges and discharges, and addition of pure water from time to time to the electrolyte to make up for loss principally at the time of charging, and regulation of charging current according to experience based on careful recorded observation, there is no reason why the cells should not remain practically unchanged through a series of years. Combined with these qualities its weight, which is about half that of existing lead batteries of the same capacity, is such that a battery of sufficient capacity to propel a pleasure vehicle one hundred and fifty miles may be incorporated in what appears to be the natural and artistic body of the vehicle. In fact the electric pleasure vehicle has distinctly the appearance of a horseless carriage.

The Edison storage cell is at present being made in five sizes known as A-4, A-6, and A-8 together with two sizes for light work known as B-2 and B-4. These sizes differ only in the provision for active material and plate surface. The increase of weight for larger sizes is somewhat less than the increase of energy output. The following table gives the dimensions, weights, discharge rate and ampere-hour output for the three larger sizes:

	A-4.
Outside measurement of can in inches...	$2\frac{9}{16} \times 5\frac{1}{8} \times 12\frac{3}{8}$
Weight of complete cell in pounds......	13.3
Normal discharge rate in amperes......	30
Rated ampere hour output............	150

	A-6.
Outside measurement of can in inches...	$3\frac{3}{4} \times 5\frac{1}{8} \times 12\frac{3}{8}$
Weight of complete cell in pounds......	19.0
Normal discharge rate in amperes......	45
Rated ampere hour output............	225

	A-8.
Outside measurement of can in inches...	$4\frac{7}{8} \times 5\frac{1}{8} \times 12\frac{3}{8}$
Weight of complete cell in pounds......	25.0
Normal discharge rate in amperes......	60
Rated ampere hour output............	300

These three types of cells have each the same height and require for clearance of pole pieces and connectors a compartment whose height is fifteen inches.

The following description which is distinctive for plate surface only, relates to a cell of type A-4.

All of the steel parts used for assembling the active elements as well as the can itself and the connecting bolts, nuts and washers are nickel-plated. After the plating process the parts are placed in sealed carbon-lined retorts arranged for the passage through of hydrogen gas during the process of annealing, which is accomplished with intense heat. By this process the nickel-plating is incorporated as a firm part of the steel surface itself. No amount of bending will cause it to peel. For both positive and negative plates the frames or grids for holding the cases containing the active materials are blanked out of sheet steel, leaving openings of such

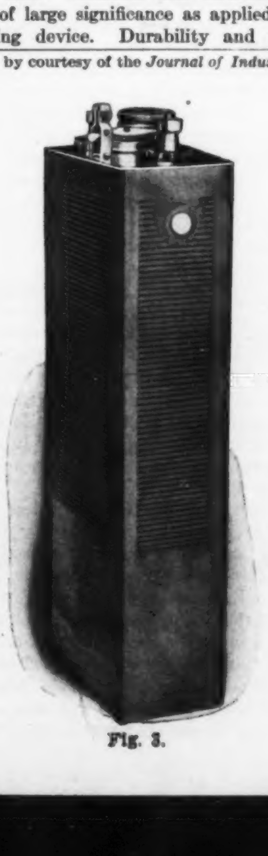


Fig. 3.

Fig. 2.

Fig. 4.

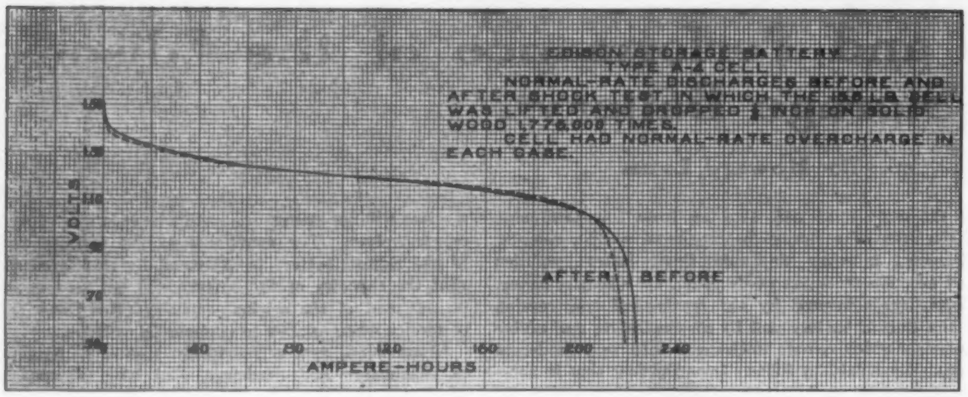


Fig. 5.

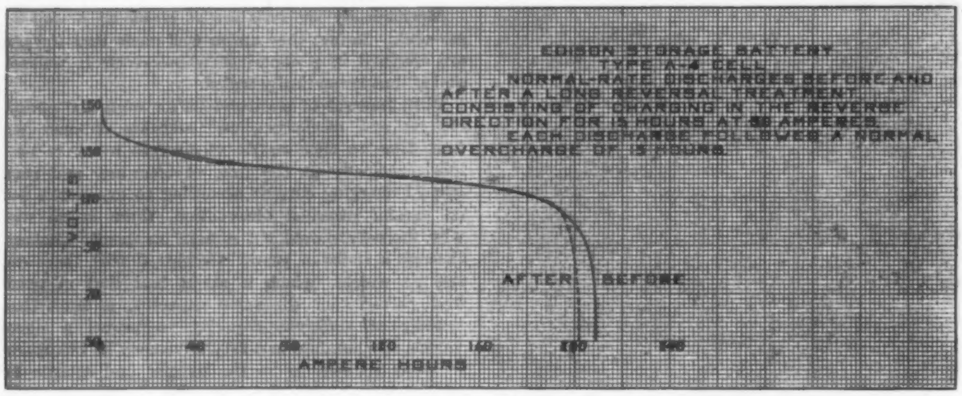


Fig. 6

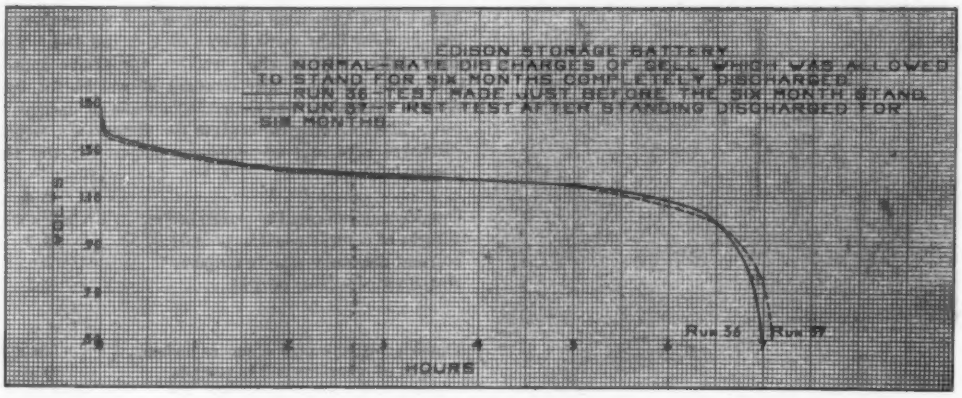


Fig. 7

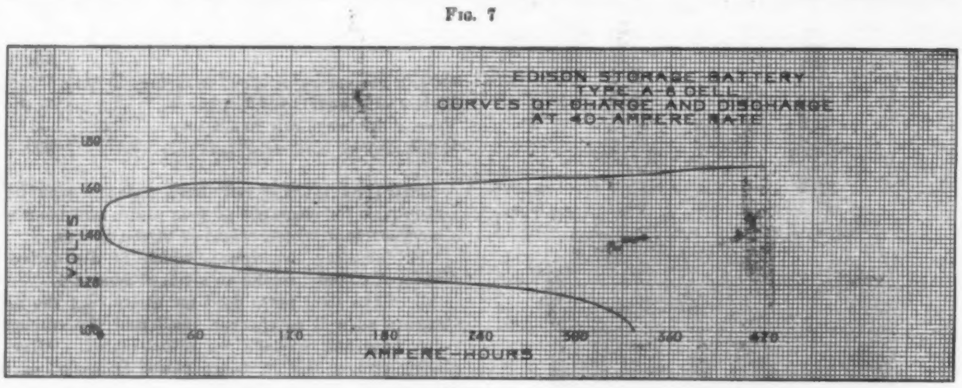


Fig. 8

size as to accommodate the required number of cases. The positive plate consists of thirty tubes in two rows. These tubes are about four inches long and one-fourth of an inch in diameter and are made of spirally rolled perforated steel ribbons, lapped and locked at the edges and reinforced by steel bands. The perforations in the walls of the tubes permit of the moistening of the nickel hydrate with the electrolyte. The ends of the tubes are flattened so that they may be assembled and clamped down by tongues on the steel grid.

The filling of the tubes for the positive plate is a most interesting one and is a triumph of inventive ingenuity. Machines have been designed to automatically fill rows of tubes and tamp the nickel hydrate and flake nickel which are fed in alternately in such quantities as to make layers approximately 1-100 of an inch in thickness for the nickel hydrate and a less thickness for the nickel flake. The nickel hydrate which is in no large measure conductive is thus brought into intimate reach of current action by thin layers or disks of nickel. In testing the distribution of active and conducting material a number of tubes are selected at random from a certain output. Cross-sections are made and the conductivity or contact of nickel flake with the walls of the tube is determined by use of a microscope and a metal stylus which is applied to successive layers with the result that an indicator gives proof of connection. Thus the number of poor connections is determined and counted. The filling is so carefully done that contact is ensured in 97 per cent of the layers. The flake-nickel is prepared as follows: With a total thickness of a sheet of paper two hundred and fifty alternate layers of copper and nickel are deposited electrolytically on rotating drums shifted by traveling cranes. These cylindrical sheets are stripped off and cut up into squares about one-sixteenth of an inch in diameter. The squares are treated with ammonia in a retort and the copper dissolved and leaving only the very thin nickel flakes. The nickel flake when washed and dried is so light that it floats in the air. There are 300 nickel hydrate units in each tube, 9,000 in each plate and 36,000 in an A-4 cell.

The iron-oxide for the negative plate is inclosed in twenty-four perforated rectangular flattened pockets crimped into place in the grids by powerful pressure. Mercury oxide added to the iron-oxide serves the same purpose in making it conductive as does nickel flake for the nickel hydrate layers.

The grids as assembled above are very light and strong, suited to withstand all shocks to which such a structure would be subjected in commercial use. Each cell of the A-4 type contains four positive and five negative plates assembled alternately with the negative plates outside. Hard rubber rods are used to space the plates. Rubber pieces also insulate the plates at the sides, edges and bottom from the steel can. The pieces of broad hard rubber at the bottom lift the plates enough above the steel surface to make a space for sediment, although in the Edison cell any deposit at the bottom of the cell will be almost wholly such as would adhere to the outside of the plates and to the walls of the perforated containers during loading. The plates of the positive and negative groups are respectively fastened by nuts to horizontal steel rods integral with the positive and negative pole pieces and distanced by steel washers. Thus assembled with the insulating pieces the elements are inclosed in a corrugated steel can.

The cover of the can has four mountings. Two of the openings are for the pole pieces, a third for the separator valve which permits the escape of gas when charging but prevents spraying, evaporation, and the spilling of the electrolyte. The fourth opening is for the purpose of adding water to replace that carried off in charging and is fitted with a cover that may be clamped down and made water-tight by a locking lever The positive and negative terminal posts are tapered to fit terminal lugs, the posts being insulated from the cover by hard rubber washers and bushings. Soft rubber packing is used about the terminals to prevent leakage or creeping o the salts. The packing ring is held down by a hard rubber nut threaded into a pocket of the cell cover.

When the cover has been properly assembled with the plates in the steel can, it is welded at the edge to the can itself by the oxy-acetylene flame, and thus the can is in effect a box of seamless steel. The corrugations of the can give maximum rigidity for a given weight or thickness of material. The cells are assembled into a battery in strong bent-wood trays and insulated and spaced from one another by hard rubber buttons which extend through the sides of the trays and fit over embosses pressed out on the sides of the steel containers. Blocks in the bottom of the tray fit into the flanged bottoms of the cells from which they are insulated by soft rubber pads. Steel terminal lugs fit the tapered pole pieces and cells are electrically connected by nickel-plated copper links swedged into the lugs.

The A and B type of cells were evolved from the earlier type E in which flake graphite was used in the positive plate to make the active material conductive. The graphite slowly oxidized and swelled and the change resulted in a diminished capacity for the cell. In the later evolved battery conduction (in the positive plate) is secured as already stated by nickel flake. Although thousands of the type E cells have been put upon the market, the manufacture of these cells was discontinued for four or five years, during which time at an expense of over two million dollars many thousand experiments were made to improve the positive element. These experiments resulted in the nickel flake and hydrate unit previously described. Rarely indeed has inventive activity been applied more vigorously or persistently to overcome difficulties than in the case of this later development of a practical storage battery. Indeed this accomplishment, measured by the skill applied and the far-reaching value of the product, may well be rated as the crowning achievement of a great inventor.

A comparison of weights of lead cells and Edison cells of the same capacity without trays shows about one-half the weight for the latter type. The space occupied by an A-4 battery with its holder is somewhat less than that of a lead battery of equal energy capacity.

Less dead weight to be carried and less space requirement for battery means a vehicle of lighter construction and consequently greater mileage capacity for the lighter and less bulky type. The normal working voltage of the Edison battery is 1.2 as compared with 1.96 volts for the lead cell. Hence for a given voltage the number of cells of the Edison and lead type required would be as 13 to 8. In the comparisons of weight and bulk this fact has of course been taken into consideration.

The first cost of a lead battery is less than that of the Edison type, but when durability is taken into consideration the added cost of renewals and maintenance for the lead battery would make a total much exceeding the initial cost of an Edison battery. Users of lead batteries have been troubled by the fact of a steadily lessening capacity with even one year's use. The Edison battery is guaranteed to retain practically its initial capacity after three years of service, such as is required in trucking.

The nature of the care required for the Edison battery

is simply addition of distilled water to make up for charging loss, the renewal of the solution at infrequent intervals and charging according to use. No attention *can* be given to the plates for they are entirely inaccessible.

The lead battery must be charged whether in use or idleness. Charging a lead cell beyond its normal rate causes rapid deterioration. The rate of charge for an Edison cell is practically limited only by the temperature developed which should not exceed 105 deg. Fahr. The limited mass in plates and electrolytes of course makes the regulation of the charging rate necessary. However, the steel cans transfer heat to surrounding air while the containers for the lead type are heat insulators.

The Edison cell has a somewhat higher resistance than the lead cell, and for this reason in hill-climbing the lead cell would have a seeming advantage in the fact that it would be possible to call upon the battery for greater current to carry the vehicle over the hill. This is only a seeming advantage, for the Edison cells and vehicle may be lighter, so that there will be less work to do and further the lead battery is structurally limited in its current output. An over-charge is distinctly destructive to its elements.

It means little to say that the lead cell is more efficient pound for pound when *new*, for the cell does not retain the initial advantage long after it is put in service. It is harassing to a user of an electric vehicle not to be able to hasten the charging rate to complete a journey. The Edison cell permits this treatment and even shows a gain of efficiency. Furthermore, the driver of an electric vehicle using the Edison battery may definitely know before he starts on his journey whether or not the current will hold out. With a given charge he is able to depend upon a given capacity by reason of the dependable character of the battery. A feature of value in relation to the Edison battery is that the capacity of the cells becomes greater with use. Overcharging expedites this betterment of the battery and is recommended by the manufacturers.

An idea of the nature of laboratory tests as applied to the Edison battery may be obtained from the following description of typical curves and from conclusions based on the inspection of the curves.

Plates Nos. 5, 6, and 7 show in a graphical way what happens to cells which have been subjected to various sorts of treatment, and especially to the treatment which has been known to be destructive to other types of storage cells. The legends accompanying the plates referred to show the nature of the laboratory test, and an inspection of the curves tells at a glance the results of various treatments.

An inspection of the curves of charge and discharge (Fig. 8) for an Edison cell shows an efficiency of 60 per cent to 65 per cent. A new lead cell shows an efficiency of 75 per cent to 80 per cent but this efficiency falls off very rapidly when the cell is put into use, while the Edison cell shows a gain in efficiency. One particular Edison battery that had given a total of 20,000 miles in delivery service showed a gain in efficiency.

The statements of the writer as related to the lead cell are based upon fifteen years of experience in use of the cell, while experience with the Edison cell of course does not extend over such a length of time. There is ample proof, however, of its much greater reliability, first in the evidence of the behavior of the battery in commercial use and secondly in the results of laboratory tests.

Efficiency is an exceedingly desirable quality in an energy-storing device, but granted even fair efficiency the availability of the stored energy after one month, six months or a year is a matter of paramount importance. Efficiency means little in economy if the structure of the device is not sturdy. As in the case of investments, a possible high rate of interest cannot be considered with the lower per cent that can be anticipated with certainty. In relation to the first cost of this battery taken with its permanency, Mr. Edison said in effect that the cost may be considered as an investment, not as a running expense.

The feature of the Edison cell that must appeal to all who use battery current for any purpose is that we have finally in portable form a store of energy that is ready for use at any moment and that may be held indefinitely without material waste. As soon as its merits become generally known it would seem that it would eventually displace every form of battery in present use.

According to the results of trial runs, it would appear that electric pleasure vehicles equipped with Edison cells should no longer be classed as town cars. This statement is made by the Edison Company.

"One hundred miles to the charge is quite ordinary, a hundred and fifty miles easy, and runs of over two hundred miles have been made." This, of course, means on a single charge.

An electric vehicle was propelled nearly to the top of Mt. Washington but finally had to turn back on account of a storm. Confirmation of the assertions

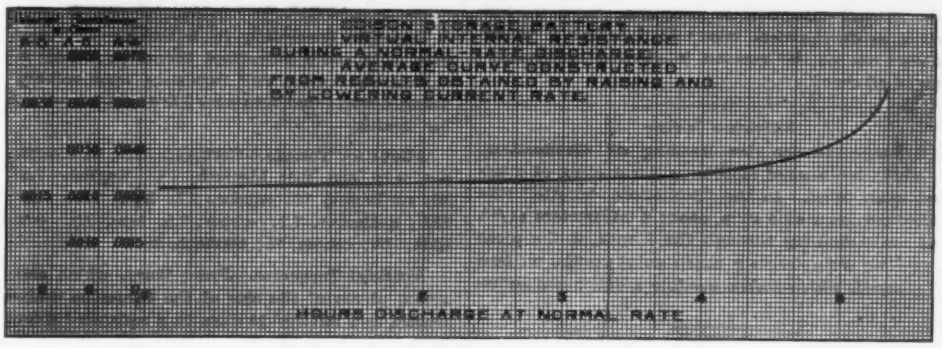


Fig. 9

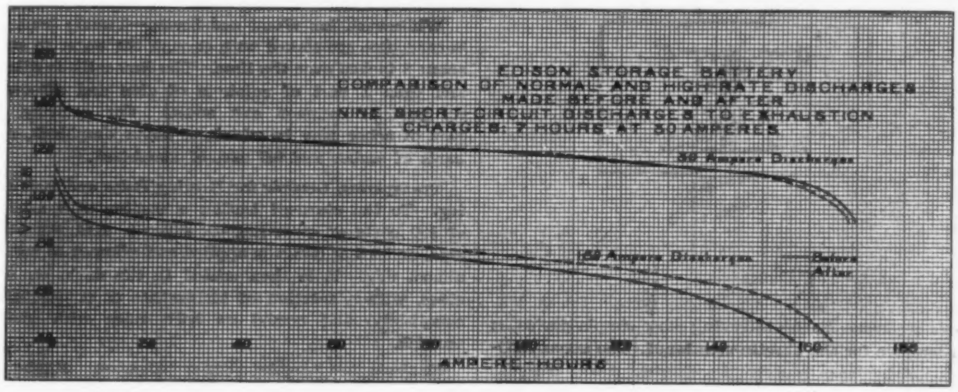


Fig. 10

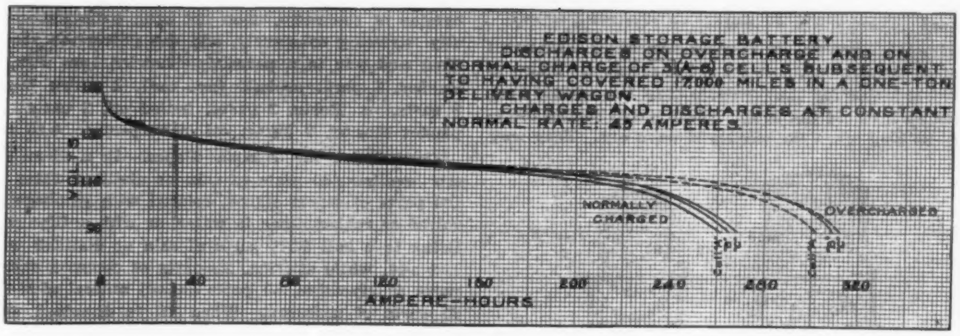


Fig. 11

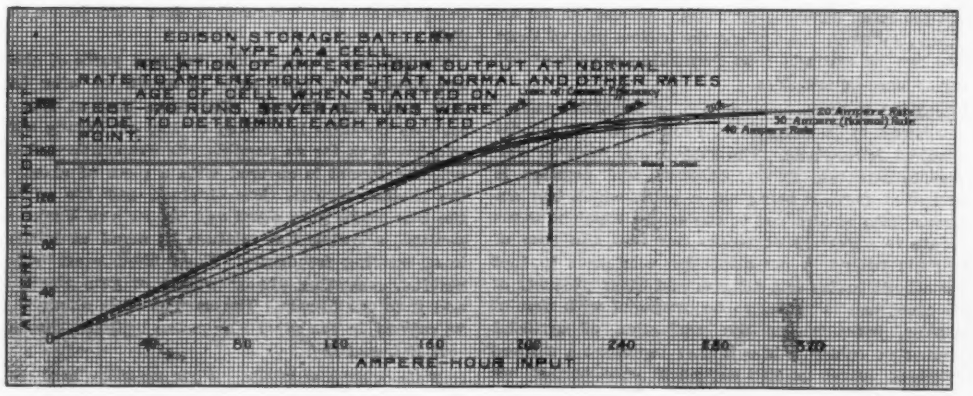


Fig. 12

in regard to dependability of the Edison battery is best furnished by experience of express companies, department stores, and large retailers who have hundreds of delivery wagons in daily use. The value of this type of energy storage is still better shown by its application to cross-town car propulsion in New York and to omnibuses and drays, a type of service that is most exacting. Two leading express companies have in use at the present time one hundred and seventy-five delivery wagons equipped with Edison batteries.

The purchaser of an electric vehicle surely need not hesitate to purchase an Edison battery, fearing that the battery may not be durable, for one manufacturer of electric vehicles absolutely guarantees to replace anything that goes wrong in the battery up to 50,000 miles of travel.

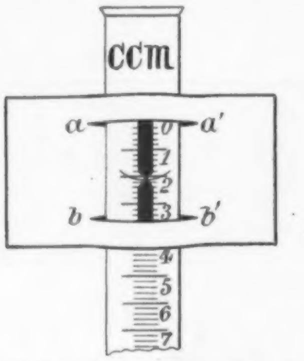
The history of the method of development of the Edison storage battery is most interesting. In answer to questions of the writer, Mr. Edison stated that all possible chemicals and structure that had been used or could be used for plates and electrolytes were considered at the outset, and cells were made up one by one as knowledge and imagination prompted the selection. Every cell was carefully tested and the behavior recorded. He said: "We had as many as eighteen hundred distinct types of cells on test at one time. We did not construct a few cells and wait a year or two for results, but crowded into the period of observation experience with thousands of cells." Finally he said with emphasis: "An individual's lifetime is far too brief to attain any marked advance in invention unless he extends his experience simultaneously to a very wide range of materials, structures and phenomena. An investigator like Luther Burbank has a great advantage over me for he can carry on millions of experiments at the same time.

The Edison battery is the result practically of the efforts of one man expended almost continuously over a period of eight years and personally directing many thousand experiments which were made. By this I do not mean the battery in a broad and general sense, but I mean the precise mechanical and chemical structure that it now is to-day, and not only that, but practically all machinery and appliances used in its manufacture are the results of Mr. Edison's personal suggestions and supervisions. He has had loyal, devoted, and hard-working assistants who have carried out his ideas with enthusiasm, but it is the Edison battery with which we are now dealing, both in fact as well as in name. In the years to come I believe it will be regarded

as the greatest monument to his genius, and if the full story of its development were told, I believe it would represent one of the greatest intellectual accomplishments of all time.

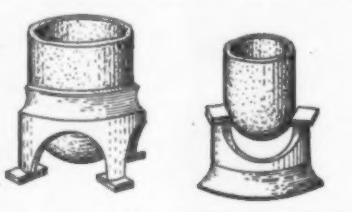
Science Notes

A Simple Device for Reading off Graduations.—A white background facilitates the reading of graduated glass tubes. In the "Schnellbach-burette" this background has a blue strip, about 2 millimeters (1/12 inch) wide running through the length of the glass tube. This strip forms a sharp point on the surface of the liquid, which makes possible a quick and accur-



ate reading of the volume of the same. Dr. J. Milbauer recommends the following most simple device as a substitute for the burette mentioned. The accompanying sketch shows plainly the details. On a smooth, glossy visiting card a line is drawn with India ink (red or blue ink). The glass tubing is inserted between the two slits *a a'* and *b b'*. The card may be moved up and down as desired.—*Chemiker Zeitung.*

Crucible Support.—It is often desired to have some sort of stand or support for a hot crucible. There is nothing better for that purpose than the mantle base from an inverted gas lamp. These pieces should therefore be kept when the mantle is worn out. They may



also be used in desiccators which often have rings or nests too large for some crucibles. As seen in the accompanying figure the top and the bottom part of these bases can be utilized, thus furnishing a support for various sizes of crucibles.

Artificial Rubber.—The subject of artificial rubber is discussed in an editorial by Prof. O. N. Witt, in his periodical *Prometheus.* The subject has received considerable attention in our columns, and mention is made of it here to bring out a point which has not hitherto been emphasized to the extent which it seems to deserve. Prof. Witt points out that the case of synthetic rubber is not altogether analogous to that of synthetic indigo and alizarin and other products of this class, and is rather to be compared with that of camphor, inasmuch as the production of artificial camphor or rubber, while it may represent a marked advantage, leaves us still dependent upon certain not very plentiful vegetable raw materials, namely, the terpenes. This is a very different situation from that which we meet in the case of synthetic indigo and the like, which are prepared from raw material that occur as waste products in the treatment of coal for the production of gas and coke. Prof. Witt points out that, in view of these facts the planters of natural rubber need entertain little solicitude on behalf of the trade in which they are interested. They have no such competitor as coal tar to fear, at any rate for the time being.

The Subsidence of Glaciers.—The French journal, *Cosmos*, quotes some interesting figures from a recent book on glaciers, by Prof. Hans Hess. According to the observations of J. Vallot, during the period from 1850 to 1907 the level of the Chamonix glacier fell by 54 meter, 55 meters, 49 meters, and 74 meters at four different points where measurements were taken. Mr. Vallot points out that in a brief half century this glacier has lost one-eighth of the depth of ice which has melted away in the extended period between the maximum of the glacier epoch and the year 1850. He further raises the question whether much of what has been stated with regard to the ice age has not been exaggerated. It would seem that geologists have not taken sufficient note of the present rate of diminution of the glaciers in their attempts to reconstruct the principal episodes of the glacial epoch.

Trade Notes and Formulæ

Tripolith (according to Schenck.)—Ordinary gypsum, with some pulverized limestone added, is very moderately burned and furnishes, upon mixing with water, a mass that sets very hard and is well adapted for casting.

Alloys for Tutania.—German: Tin, 91.4 parts; copper, 0.7; lead, 0.3; bismuth, 7.6. English: (*a*) Tin, 80; antimony, 16; copper, 2.7; lead, 1.3. (*b*) Tin, 88.5; antimony, 7.1; copper, 3.5; lead, 0.9. (*c*) Antimony, 50; copper, 25; bismuth, 25.

Artificial Turquoise.—From ivory, which shows no grain, pieces of the size of the turquoise desired are shaped and left for 14 days in a saturated solution of ammoniacal copper oxide in water, then rinse and dry them. If the color of the turquoise is not deep enough, the operation may be repeated.

Whitewash for Wood and Stone.—Twenty parts of burned lime are slaked with enough hot water to stand about 6 inches over the lime. The lime-milk is diluted and then 1 part of sulphate of zinc and afterward 0.5 part of common salt added. For coloring, 1.5 part of ocher may be added, or some lampblack, or 2 parts of umber and 0.5 part of lampblack.

Transparent Leather for Driving Belts and Belt Lacing.—To the cleansed leather a coating of a mixture of 100 parts of glycerine, 0.2 salicylic acid, 0.2 picric acid, and 2.5 of borax is applied and allowed to become almost dry. It is then coated in the dark, on both sides, with a solution of bichromate of potash, dried completely, and coated on both sides with shellac varnish.

Mixture for Coating Paper Toys.—*a.* Rubber, 1 part; shellac, 2 parts; benzol, 12 parts. Cut the rubber into fine strips and by stirring constantly effect its solution in the benzol. Then set the vessel, outside of the room, upon hot sand bath and gradually, strirring constantly, add the pulverized shellac. Heat and stir in a porcelain-enameled iron dish. *b.* Rubber, 1 part; asphalt (not tar), 2 parts; benzol, 2 parts. *c.* Rosin, 2 parts; boiled oil, 2 parts; fine plaster mortar, 2 parts; oil of turpentine, 0.25 part.

Composition for Transfer Paper.—In a clean dish stir together 400 parts of rain or distilled water and 100 parts of wheat starch, colored with gamboge dissolved or rubbed down in water, or with aniline color. Bring to a boil 1,000 parts of rain or distilled water and add, while stirring, 25 parts of common salt, 70 parts of glycerine, 50 parts soaked animal glue, and 25 parts of molasses. When all is dissolved, pour, stirring constantly, the stirred up starch into the boiling water and allow it to boil up a little. After boiling up, remove it from the fire, stir until cold and press the starch through a clean cloth into a clean dish.

Varnish for Tinfoil.—Two hundred parts of shellac are dissolved in 1,000 parts of spirits of wine (alcohol) and then filtered. The foam that at first collects on the filter is allowed to drip off, during which, to prevent as far as possible, the evaporation of alcohol, the funnel is covered with a piece of glass. To the shellac varnish thus obtained add 100 parts of the best white gum elemi and 25 parts of Venice turpentine, allowing the mixture to stand at moderate heat, stirring frequently. Then filter, press out the residue, consisting almost wholly of gum elemi, and add it to the filtrate. The varnish thus obtained can be colored in the same manner as brilliant varnishes. —*N. Erf. und Erf.*

Fula or Russian Niello.—First an alloy is prepared of silver, 1 part; copper, 5 parts; lead, 7 parts; and a mixture made of powdered sulphur, 4 parts; powdered borax, 24 parts; sal ammoniac, 4 parts; the sal ammoniac being dissolved in as little water as possible and the solution made into a paste with the powders of sulphur and borax, a crucible lined with the mixture and well dried in a warm place. The crucible is then placed in the fire, and the molten alloy poured into it and heated with a coating of melted borax forms a floating cover to the mass. The contents are then poured into water, the solidified mass pulverized and with a solution of sal ammoniac in water applied to the depressions of the object to be niello-enameled.

Driers for Quick Drying Paints and Varnishes.—(*a*) Linseed oil of good quality, 7 parts; red lead, 2 parts; pulverized litharge, 2 parts; sugar of lead, 1 part; boiled. (*b*) Seven parts of linseed oil, 2 parts flake brown, 2 parts manganese, 1 part red lead. (*c*) Seven parts linseed oil, 2 parts sugar of lead, 2 parts red lead. (*d*) Seven parts linseed oil, 1 part umber, 1 part flake brown, 1 part red lead, 1 part sugar of lead. All the above described are decanted with 16 parts of rectified oil of turpentine as hot as possible and used as an addition to melted copal as follows: To 2 parts of melted copal add 0.5 part linseed oil and of one of the above solutions, the linseed oil mixture in 6 parts of oil of turpentine, and then a further 14 parts of rectified oil of turpentine added, stirring constantly.

Electrical Notes.

Selenium for Burglar Alarms.—The property of selenium of becoming conducting to electricity when exposed to light, is to be made use of for the construction of burglar alarms. A selenium cell is inserted in an ordinary electric circuit comprising a bell and a battery. During the day the cell is kept covered, sheltered from the light. At night the cover is removed. Any light then falling upon the cell closes the circuit, and sounds the alarm bell.—*Zeitschr. f. Schlosserei.*

Determination of Longitude by Wireless in Argentine.—The triangulation of the Plata River, which is being carried out by the Argentinian navy, entailed the determination of an astronomically well-fixed point of connection at Montevideo. The favorable situation of the local radio-telegraphic station suggested the use of wireless telegraphy for performing this determination of longitude. Apart from the work done some years ago by the Geodetical Institute at Potsdam, this is the first application of radio-telegraphy to a work of precision carried to the one-thousandth part of a second. After some laborious preliminary experiments, satisfactory results were obtained, thanks to the active co-operation of the manager of the Uruguayan Telefunken station and another telegraph official who converted the navy station at Darsena Norte into a transmitter suitable for this special purpose. The signals sent out at given intervals from Darsena station are recorded simultaneously at Montevideo station and at the Buenos Aires Institute of Military Geography, which serve as points of connection. The wave impulses arriving through the ether are recorded automatically by a coherer on the paper tape of a chronograph registering at the same time the seconds of a precision chronometer. The astronomical observations required to ascertain the position are made at Buenos Aires by the Institute of Military Geography and at Montevideo by Dr. Schulz, who has to this effect installed a large transit instrument in the neighborhood of the Telefunken station.

Thawing a Frozen Pipe by Electricity.—Mr. Charles Smeeth, writing in the *Electrical World*, says: "The following may be of interest to readers who, in the coming winter, may find information on the subject useful. Last winter the writer was called on to thaw out a 2-inch main in a distant part of the city. It was ascertained that a single-phase, 2,300-volt line ran past the frozen main, and that a 30-kilowatt transformer was available. While looking around for some form of resistance or reactance it occurred to the writer that under the conditions nothing of this kind was needed, and the following method was successfully carried out: The line that ran past the frozen main was disconnected from the switchboard and connected to an idle alternator with an ammeter in circuit. The transformer was then hauled to the point where the pipe was frozen and connected up, the primaries being connected in the usual way and the secondaries spliced for their lowest voltage, which was 110 volts, and connected directly to the frozen main. The attendant at the power station was then communicated with and instructed to start up the alternator slowly (field exciter) until the ammeter indicated 15 amperes. It was expected that under the conditions the alternator would be running considerably under speed, but the attendant found that by keeping the exciting current low he could run at usual speed, thus keeping the frequency at its normal value. The primary voltage at the power house was 1,800 volts. Twenty-four minutes sufficed to thaw the pipe, and this without reactances or resistances or trouble of any kind."

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